THE MODELING OF HUMAN INTELLIGENCE IN THE COMPUTER AS DEMONSTRATED IN THE GAME OF DIPLOMAT

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THESIS

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ABSTRACT

The purpose of this thesis is a discussion of developing human-like behavior in the computer. A theory of the human learning processes is first described. This leads to the presentation of a computer game which simulates the human capabilities of reasoning and learning. The program is required to make intelligent decisions based on past experiences and critical analysis of the present situation.

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I. INTRODUCTION

In the past few years, much attention in the computer world has been given to the study and development of Artificial Intelligence. One goal of artificial intelligence is to develop human-like qualities in the computer. One method of patterning human behavior is achieved by giving the computer the ability to (1) absorb data, (2) use inductive reasoning to make generalizations based on the data and abstract information from the data, (3) make decisions based on these abstractions and generalizations, and (4) learn from past experience. Admittedly this seems to be an enormous task, and in fact it is, yet this is how a child learns. To go one step further in modeling human behavior, and at the same time provide a reasonable limit on the size of the computer required, the ability to "forget" long-past experience could be developed in the system.

The theory of the human learning process is discussed first in this thesis. The theory leads to the development of a computer program that learns based on data gathered from past experiences. The program uses its library of stored knowledge in making decisions. The example which is presented is a game named DIPLOMAT which simulates the representatives of two nations interacting in strategic negotiations regarding relative strengths, i.e., armaments. The game is played between two opponents, the computer and a person.

The authors of the thesis consider that the interaction of the computer and a human in a decision-making environment is an excellent way of demonstrating the ability of the computer to develop human-like behavior.

II. THEORY

One of the objectives of artificial intelligence is to build a computer system that will effectively mimic the human learning process. This would be an enormous task if the system were to be so general in nature that it could handle any conceivable task, because it would involve representing the external world in a form adaptable for the computer. When restricted to a small subset of the world, i.e., confined to one or two specific tasks, attempts at this objective have been fairly successful in that the systems do mimic and sometimes surpass the human in their performance in these areas. However when trying to model the human brain in the general sense, the problem has been found to be extremely complex.

A possible approach to the problem would be to model the human brain using the physiological approach, i.e., to build the exact electrical network of sensors, storages, and connectors that form the physical makeup of the brain. Obviously this is impractical because the brain is composed of so many cells. Dr. R. L. Beurle, a noted English authority on artificial intelligence [Ref. 3] who has extensively studied the theory of brain models, estimates that the brain is composed of approximately 10^{10} neurons (nerve cells).

Another approach to the problem might be the psychological approach. In this approach, it is necessary to model the logical structure of the brain rather than the physical structure. However in order to use this approach, some knowledge of the process of psychological development of human behavior must be obtained. It would be best to trace the learning processes from their beginning in a child, since a knowledge of

total human behavior usually requires almost a lifetime of study and experience.

In the area of the development of the mental abilities of the child, the works of one man stand out above all others - the works of Jean Piaget. Jean Piaget is a noted Swiss child psychologist who was educated at Hevchotel, Zurich, and the University of Paris. He has been a professor of child psychology and history of scientific thought at the University of Geneva since 1929, and is the director of the International Bureau of Education at the Institute J. J. Rousseau. Above all, he is noted for his research in the development of the mind from birth to adolescence.

The works of Jean Piaget, as presented in References 9 through 11, form the basis of this section on the theory of the development of the human learning process. They are supported by References 15 and 16, which are basic references used in the American medical profession.

A. THE LEARNING PROCESS OF THE HUMAN MIND

Piaget contends that the human mind consists of a finite number of structures, each consisting of a finite number of cells. Each of these cells contains an element of information which is a part of the human thought process. He theorizes that there is a separate set of information structures for each function of the central nervous system which is composed of the brain and spinal cord. Many of these separate sets of structures are developed before birth, for example, a set controlling the action of the heart, another the function of breathing, a third controlling the flexing of the arms and legs. Piaget further contends that as relationships build, these structures are linked together to produce automatic reflexes and in general the structures are reordered

and enlarged in successive phases. The central theme for the human learning process is then the process of manipulation of the information structures, i.e., the building, storing, linking, rebuilding and re-linking of elements of information.

It is easiest to describe the manipulating of these information structures by studying the development of the brain of the newborn baby. This is the approach presented by Piaget. At birth the cerebral cortex, which is composed principally of neurons, is largely undeveloped, and the infant is basically a reflex organism. The reflexes are the result of the manipulation of the information structures before birth. Other than the regular actions of the heart and other vital systems, most muscle activity is random, lacking direction from the brain.

One of the first learning processes of the infant is the learning of spatial relationships. While flexing his arms and legs, he touches the side of the crib. Relationships are built in his mind between the information structures for the sense of touch and those of muscle control, and a new structure built up regarding an awareness of the confining walls of the crib. These structures become libraries of information. Other libraries build up, for example he grows to associate his mother with warmth, comfort, and nourishment. The building of relationships between the structures, and the reordering of the structures and links, forms an associative memory within the brain.

It is important in the study of the human brain to understand that these activities are the result of relationships between the libraries even though the information in their structures is dissimilar. Once the links are established, the dissimilar sets function together. The act of crying which is the result of combining the structures of muscle control,

an awareness of a specific need, respiration control, and others is a good example. The operation that is accomplished constitutes some action of uniting or separating, placing or displacing, arranging or disarranging elements of information into sets of structures. As the relationships develop within the brain, the mind learns how to use the data which has been structured within its memory to produce a desired result, such as rolling over or sitting up.

B. REPRESENTATION OF THE HUMAN LEARNING PROCESS

The process of thought is the result of the human becoming aware of the relationships that link cell structures in the associative memory of his brain. Piaget explains the mechanism of thought as a movement which evolves when an awareness of the relationships becomes sufficiently advanced to permit the individual to combine the information from several structures into a single idea. The resulting thought may cause other reactions such as body movement, and thus may cause new structures to be created or new links to be built. The actual process involved in the human brain in conceiving a thought is not definitely known, and must be extremely complicated. If such a scheme is to be computerized, however, it must be made deterministic.

In an attempt to make the process a deterministic one, it is necessary to summarize some facts deduced from the discussion of Piaget's works. One result of the thought process is the acquiring of an idea, which is the outcome of the interaction of cells or structures. The combination of old structures in a new way may lead to new and possibly improved concepts. The new relationships may be formed by applying deductive reasoning to some information extracted from the interconnected structures. In this way, the learning of a new concept may be achieved.

Thus learning is not merely an additive process, i.e., the piling of one disjoint piece of information atop another and another and another.

The number of cells or structures is not the criteria for learning, rather it is the effective combining of the stored information that results in intelligence. Once a certain point is reached in the process of human development, the physical size of the brain does not rapidly become larger and larger, rather information is restructured, old information may be forgotten and new information stored in its place, and new links established.

These two techniques, structuring of memory and learning by interaction of the structured information, are utilized in the structuring of a computer memory and the development of a program which will exhibit deductive reasoning based on learning. This is the example presented in this thesis. Considerable research and soul searching went into formulating a worthwhile application for the model of human intelligence. The application had to be general enough to apply to real-life situations, yet not overly complicated.

C. BACKGROUND OF THE GAME OF DIPLOMAT

Several recent periodicals have been devoting considerable attention to games as an application of artificial intelligence. One game in particular has been the subject of much of the attention, the game known as the Prisoner's Dilemma. The classic prisoner's dilemma is described in reference 7 as follows:

> "Two suspects are taken into custody and separated. The district attorney is certain that they are guilty of a specific crime, but he does not have adequate evidence to convict them at a trial. He points out to each prisoner that each has two alternatives: to confess to the crime the police are sure they have done, or not to confess. If they both do not confess, then

> the district attorney states he will book them on some minor trumped-up charge such as petty larceny and illegal possession of a weapon, and they will both receive minor punishment; if they both confess they will be prosecuted, but he will recommend less than the most severe sentence; but if one confesses and the other does not, then the confessor will receive lenient treatment for turning state's evidence, whereas the latter will get 'the book' slapped at him."

One reason the prisoner's dilemma has been discussed so much is that there are numerous situations in the world that have some of the characteristics of this game (or extensions from this game such as the addition of participants and/or strategies). Most economic situations that require a choice among a finite number of strategies have these characteristics. Consider, for example, gasoline service stations located close to one another, each of which can lower its prices. Regardless of the price one's competitors set, any one manager is better off, in the short run at least, cutting his price. If all cut prices, however, the total volume of business is the same as if none cut prices, but the total revenue is less. On a larger scale, consider wheat farmers in a country without governmental price and production controls. Any one farmer is better off producing wheat as long as his marginal cost is not greater than the price. He will be able to sell all he can produce at the going market rate without affecting the price. If all farmers produce maximum amounts, however, the price will be pushed down and all will be worse off than if each had restricted his production. On the worldwide scale, there is the problem of disarmament. One country can be more powerful (or secure) by arming, but nothing is gained if all arm. All countries would be better off if all disarmed in that the money not spent on defnese could be spent for, say, consumer goods or for correcting social ills.

More interesting than the one-time classic prisoner's dilemma is the iterated game, i.e., a game composed of many moves. In the overall

picture of the iterated game, each player must (in general) forsake the possibility of maximizing his own short-run profit to enjoy the greatest payoff by maximizing his long-run profit. With a one-trial game and an unknown rival, it is difficult to imagine the wisdom of choosing a medium-gain, little-risk, cooperating type strategy, when more can be gained (or lost) by choosing the high-risk high-payoff strategy (nothing ventured, nothing gained). The single trial situation eliminates both the possibility of future cooperation and the possibility of punishing a rival for non-cooperative action in one trial. Dr. Lester B. Lave of the Carnegie Institute of Technology [Ref. 6] has studied factors affecting cooperation in prisoner's dilemma type games. He has found that the single-trial game and the multi-trial game are basically equivalent in the formal sense in that the expected values of the two games have the same range across different <u>groups</u> of opponents. However, the games are quite different with respect to negotiating cooperation among different participants. The expected values of the two games are not equal for a <u>given rival</u>, since certain forms of behavior can induce cooperation or competition. He based these results on experiments conducted using human competitors only, and did not introduce computer gaming into his research. He further found through experimentation that when a game was iterated, it was possible to display behavior that induces or stifles cooperation. He also found that it was possible for the players to develop communication between them using the choices in the game, but that this rudimentary form of communication took time to establish and function. He found that the longer the game, the more likely it was that a stable cooperative solution could be achieved.

Other experiments with a complex decision task showed that experience from previous tasks was a large factor in success. The conclusions

drawn from studies conducted at the Human Performance Center, Ohio State University, [Ref. 13] were that after gaining experience when tested under realistic circumstances, the experienced subjects were in general less conservative than naive subjects who received no such prior training. They were willing to take more risks to achieve higher overall gains.

The study of concept attainment by the machine has also been the subject of study. In order for a human to play a game of this nature, he must be able to form a few concepts of the game itself and of his opponent. It can be likened to the game of poker in that opponents must deduce the type of individuals playing the game. Dr. Frank B. Baker, a professor of educational psychology at the University of Wisconsin, has studied the theory of concept attainment and developed a computer program which demonstrated the theory in a simple decision task requiring the identification of common attributes among different sets [Ref. 1]. In Reference 2, Dr. Baker states:

> "If computer programs are to serve as useful models of congnitive behavior, their creators cannot avoid coming to grips with the necessity for establishing an internal organization for their model which implements the higher level cognitive behavior associated with the human capacity for self-direction, autocriticism, and adaptation."

In computer game playing, the concept of the game itself is built into the game, however the concept of different methods of play or types of strategies that the computer may face is something that must be attained as it plays.

Most of the behavioral tests conducted to date have been between humans. However, in the past few years, more attention has been devoted to simulating these tests on the computer using interaction between man and the machine. Professor Roman J. Weil of the University of Chicago stated in Reference 18 the advantage of using the computer for this application quite well:

"The philosophy underlying the computer approach is this: If a program can be constructed that, when placed in a prisoner's dilemma situation, exhibits behavior like the behavior of people when placed in the same situation, then that program will be a powerful tool for generalizations."

Professor Weil goes on to say that if the computer can be made to simulate the human in organizing data and making decisions under all simulated conditions of risk and stress, it will be possible to accumulate more data and more accurately predict human behavior in the same environment.

The game of DIPLOMAT presented in this thesis is basically an extended version of the prisoner's dilemma. It incorporates an iterated game technique with the game lasting anywhere from ten to fifty moves, and two opponents choosing from among three strategies. Additional complications to the prisoner's dilemma basis are inserted by varying the payoffs to the participants as a function of previous moves, and by inserting an unknown random variance into the payoff table.

In order to be successful in this game, the participants must perform most of the tasks listed in the introduction as a goal of artifical intelligence, in addition to performing the task of concept attainment. In particular, the computer must analyze the situation of the game at the time of the move and refer to past games and past moves in the present game to determine its opponent's probable strategy. It must then abstract enough information from his prior and present knowledge to select a strategy, and correctly analyze the results of the move in order to store (remember) meaningful experience. In addition, it must form concepts regarding the reliability or honesty of its opponents. The participants in this game may or may not be completely truthful in their

negotiations, which is certainly characteristic of actual diplomats at the conference table. The computer, then, must form estimates of its opponent's reliability and factor this into its selection of a strategy.

In the first game played, the computer has no prior knowledge upon which to draw, and so must reason from an analysis of the present situation. With each move however, the system acquires more experience and thus has a better base from which to draw in selecting strategies. When the computer plays its second game, it has the experience of the first, with one winning and one losing strategy, to use for reference. In general, the more games it has played, the more experienced it is and the better it performs in making important decisions.

III. THE GAME

DIPLOMAT models the representatives of two nations interacting in strategic negotiations regarding armaments. It is basically a non-zero-sum two person rectangular game, using the phraseology of formal game theory. Each nation is given three choices of possible strategies regarding armaments:

Strategy 1: Increase Armaments (Arm)
Strategy 2: Maintain the Status Quo
Strategy 3: Decrease Armaments (Disarm)

The following basic concepts govern the decision of the strategy to be followed by each side:

Each nation starts the game with zero strength and zero wealth, where "zero" implies a deviation from the average rather than absolute zero.

Arming increases strength by one unit, disarming decreases strength by one unit, and maintaining the status quo does not change strength. Arming costs money decreasing wealth, disarming gains wealth, and maintaining the status quo may increase or decrease wealth, depending on the strength of the player: If the player is strong in armaments, it will cost him more for upkeep and maintenance and hence decrease wealth; if the player is weak, armament upkeep is low and maintaining the status quo should gain some wealth. The basic changes in wealth for the different strategies are shown as a function of strength of the player in Table I.

Strength	STRATEGY 1	2	3
$S < -6$	0	3	3
$-6 \leq S < -4$	0	2	3
$-4 \leq S \leq -2$	-1	2	3
$-2 < S < +2$	-2	1	4
$+2 \leq S \leq +4$	-3	0	3
$+4 < S \leq +6$	-4	-2	3
$S > +6$	-6	-3	2

Table I
Wealth Changes Versus Strategies As
a Function of Player Strength

Changes to the basic values in Table I are generated by a random integer amount between the values of -2 and +2. These changes, which are to simulate economic conditions, are generated at random times during the game; hence, a given economic condition may last for only one move or for many moves. The economic condition for each player may be different, as each opponent uses a different random number generated from the same random number seed. The economic condition in effect for each player is not furnished to either opponent, but must be estimated based on the results of each move. The economic conditions of -2 and -1 mimic those times when prices are high, and the conditions of +1 and +2 mimic those times when the cost of living is relatively low. These values are added to the basic wealth change values of Table I to determine the actual wealth changes for the strategies chosen.

Point values for each participant are determined after each move according to the formula:

$$\text{POINTS} = \begin{array}{c}\text{(Previous)}\\ \text{Points}\end{array} + 2 \text{ X } \begin{array}{c}\text{(Wealth)}\\ \text{Change}\end{array} + 5 \text{ X } \begin{array}{c}\text{(Strength)}\\ \text{Change}\end{array}$$

Bonus points are given for the following combinations of strategies:

If both opponents cooperate in disarming, each receives two bonus points as a reward for their cooperation.

If both opponents arm, each receives -1 bonus point, because both have spent money without acquiring any relative advantage.

If one side arms and the other disarms, the opponent who arms is awarded four bonus points for "outfoxing" the other.

The length of the game is at least ten and at most fifty moves. Between these values, a random selection is used for the decision to end the game; as the number of moves increases, the greater the chance of random termination. Experience has indicated that the average length of the game is twenty moves.

The winner of the game is decided by one of three methods:

Normal Termination: The participant with the most POINTS at the end of the game is declared the winner.

Abnormal Termination: The game may be abnormally terminated, even before ten moves have been completed, in two ways. The game is stopped if one nation's wealth becomes thirty units greater than the other, and the richer nation is declared the winner. Similarly, if one participant becomes stronger in armaments than the other by ten units, the game is stopped and the stronger nation is declared the winner.

In playing the game of DIPLOMAT, each side initially declares a proposed strategy called that participant's Concession Point, with each side taking turns declaring the first concession point. The proposal of each player is used as an aid in deciding that player's probable actual strategy. After both concession points have been declared, the computer's

move is locked into the system and the human participant is asked to declare his final strategy for that move. Of course, the concession point and the strategy need not be the same, but wisdom must be used in selecting proposals versus actual strategies in order to maintain a high degree of reliability, yet keep the opponent off guard as to the actual strategy to be chosen.

The program is written as a main routine which controls the running of the game itself, and forty-one subroutines. Seven of the subroutines assist in controlling the game and in performing list-processing chores, nine of the subroutines assist the program in accomplishing its reasoning capabilities, and the other twenty-five subroutines are necessary for accomplishing the task of learning. Among the tasks performed by these forty-one subroutines are setting up the memory, saving and restoring experience, selecting a strategy and a concession point, determining the opponent's reliability, pattern matching data from previous games and moves to take advantage of prior experience, and so forth. The program is written in the FORTRAN IV language, and is designed to operate on-line on a computer terminal using the Cambridge Monitor System. A complete listing of the program is contained in Appendix C.

Figure 1 is a macro-flowchart of the game. DIPLOMAT progresses in the following manner:

After initializing counters, point values, and payoff tables, the system sets up the memory cells in an associative memory structure, filling in the data from previous games. The initial economic conditions are also determined.

The player (hereafter called SOUTH) signs into the system with his name. The computer program (hereafter called NORTH) then

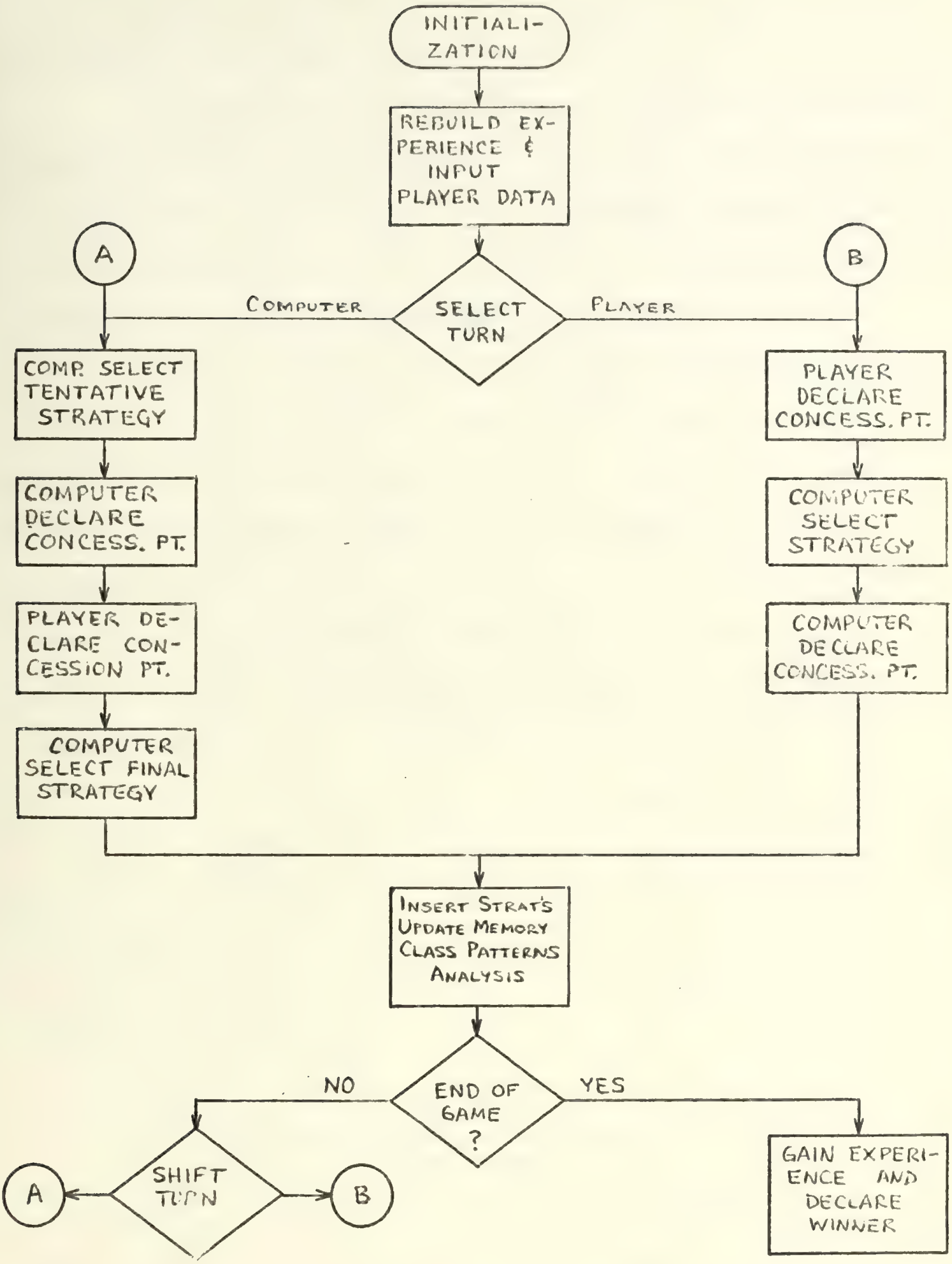


Figure 1. Macro Flowchart of the Game DIPLOMAT

checks to see if he has played this opponent before, and if so brings his history to the top of the catalog of players.

The player inputs a random integer number for use as a seed in generating random numbers throughout the program. The computer simulates flipping a coin to see who will make the first proposal during the first move. SOUTH calls the flip of the coin. (In the discussion which follows, it will be assumed that SOUTH won the toss).

Having won the toss of the coin, SOUTH must make the first concession point. To aid him in making his selection of a proposal and ultimately of a strategy, a payoff matrix is presented to him showing the approximate payoffs to SOUTH (relative to NORTH) for the various combinations of strategies. Approximate payoffs are shown rather than actual because neither SOUTH nor NORTH have access to the existing economic conditions. A sample payoff matrix as presented to SOUTH is shown in Figure 2.

```
                                    SOUTH
STRATEGY                  1           2           3
                      ****************************
                      *
      N    1          *   -1          1           2
      O               *
      R    2          *   -1          0           1
      T               *
      H    3          *    2         -1           2
```

Figure 2

Approximate Payoff Matrix Presented to Player (SOUTH)

The approximate payoff matrix changes according to the strengths of NORTH and SOUTH because of the differences in wealth for the various strategies as shown in Table I.

SOUTH may propose a concession point of 1 (arming), 2 (maintaining the status quo), or 3 (disarming). NORTH then considers SOUTH's concession point, attempts to determine if SOUTH is being honest, analyzes his payoff matrix, and responds to SOUTH with his concession point. NORTH also decides upon a strategy at this time.

SOUTH considers NORTH's concession point and decides upon a strategy for the move. Both sides then enter their strategies into the system and the results are tabulated and presented for analysis by both participants.

For the next move, NORTH will declare his concession point first. The game proceeds in this manner, alternating between NORTH and SOUTH as to who is first to declare a concession point. After each move, each side analyzes the results in order to determine the economic conditions in effect. After ten moves have been completed and after each move thereafter, a random number is generated and tested to determine if the game should end.

At the end of each move, changes to the payoff tables generated as a result of changing strengths of the participants are calculated and inserted into the system, and it is determined if it is time to change the economic conditions. If so, they are calculated and inserted into the game.

A sample output of the program as exhibited at the counter terminal is located in Appendix B.

In playing this game, the computer program maintains data regarding past moves and past games in order to draw upon this experience in selecting strategies and concession points in future moves and in future

games. It thus forms concepts of each player as it proceeds. At the end of each move, some of the learning subroutines are called upon to update the short-term memory in order to store data for use in playing the game in progress and for maintaining running totals. At the end of the game, others of these subroutines calculate the game totals and determine the characteristics exhibited by both participants for inclusion in the long-term memory. This is the experience gained by the program from this game.

The data which forms the experience is kept in an associative memory structure mainly for ease of manipulation, but it is considered that this patterns the human in organizing data and experiences in his mind. In studies conducted of neural nets, it has been found that the human will take data, organize it into logical structures based on determining relationships between units of the data, and store it in an associative net accordingly [Ref.s 2 and 3].

Diagrams of the memory structure of DIPLOMAT are contained in Appendix A, and were conceived by the authors after critical analysis of the structure of data maintained about players during hand simulation of the game.

Besides exhibiting the human attribute of learning by storing away past experiences, the program mimics the human in its reasoning capability in deciding upon strategies and concession points. The method of reasoning was also patterned after analysis of the mental reasoning used during hand simulation of the game. These two attributes of reasoning and learning are discussed in greater detail in the sections which follow.

A. THE REASONING PROCESSES

Two of the subroutines of the program are designed to mimic the reasoning processes of the human. These are the strategy decision subroutine (STRTGY) and the concession point decision subroutine (CPNDCN). These subroutines in turn call on many other subroutines to determine optimum strategies, probable moves of the opponent, next moves of the computer, and so forth. Both the strategy and concession point decision subroutines were written based on the thought processes used by the authors in playing the game by hand.

1. Subroutine STRTGY

This subroutine has three main functions. The first is that of strategy decision based on an analysis of all the factors available. This decision is final if the player's concession point is known, otherwise it is a tentative decision until the declaration of SOUTH's concession point. The second function is that of reconsideration of the tentative strategy after SOUTH has declared his concession point, and results in the final selection of a strategy. This function is called upon only if NORTH was first to declare a concession point. The third function is analysis of the completed move in order to determine if a better choice of strategy could have been made. If so, an adjustment of the calculations performed in the decision portion of the routine is accomplished.

Macro-flowcharts of STRTGY are shown in Figures 3 and 4. The subroutine may be called upon either two or three times each move, depending upon who submits the first proposal. A series of flags are used to determine for which function the subroutine is being called. The algorithm for making this determination is shown in Figure 3.

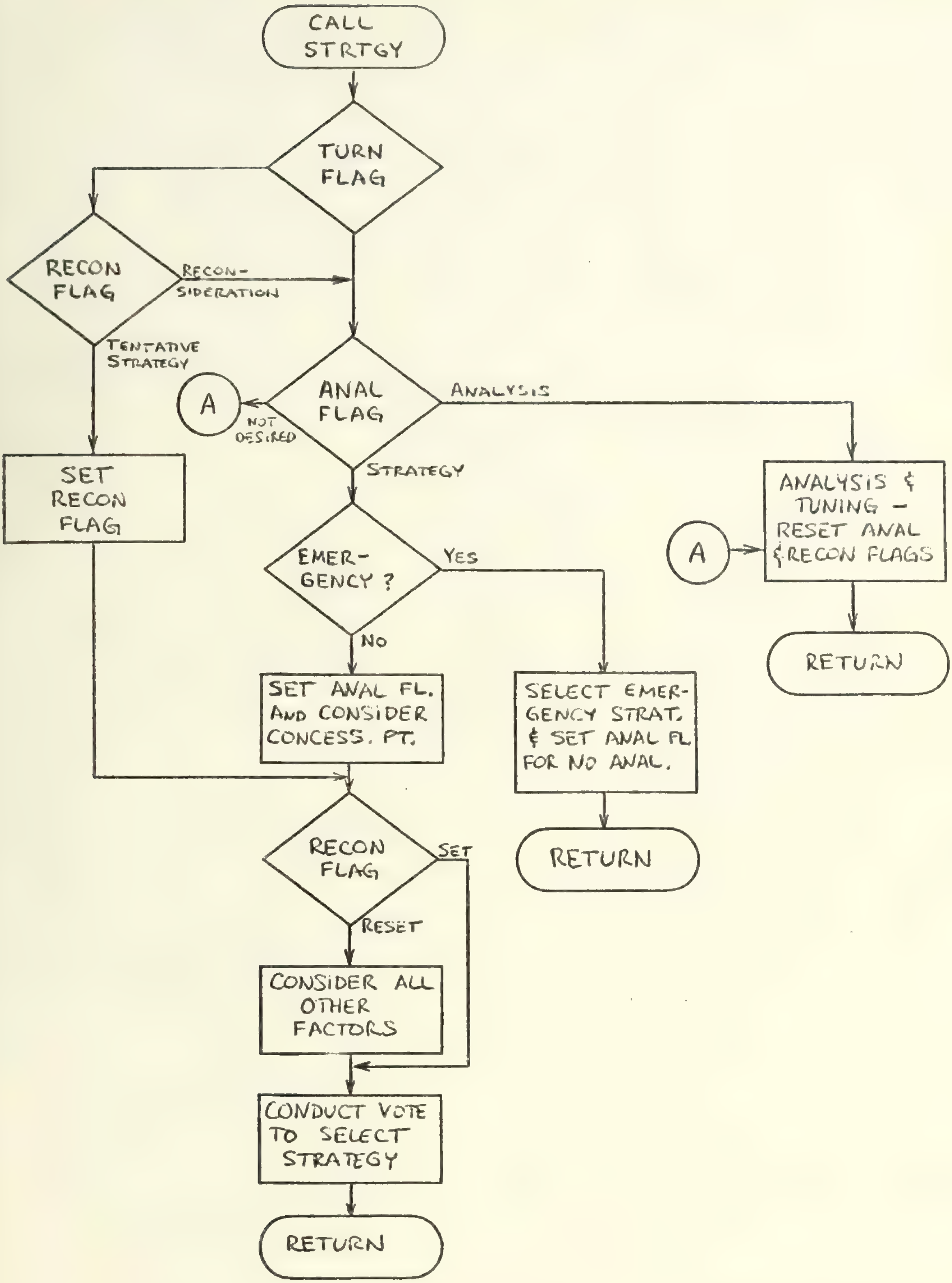


Figure 3. Macro Flowchart of Subroutine STRTGY Indicating Determination of the Desired Function

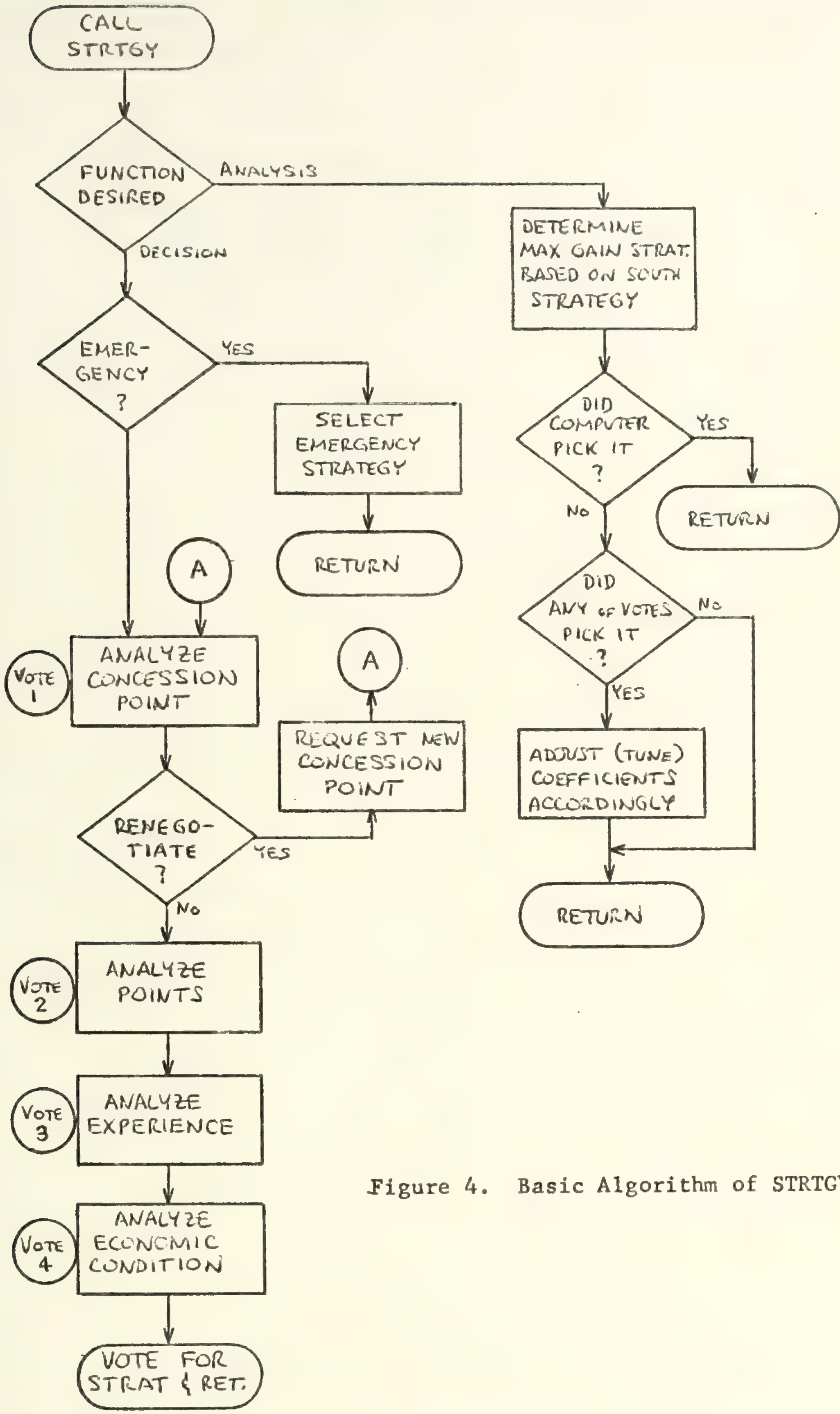


Figure 4. Basic Algorithm of STRTGY

Figure 4 provides the basic algorithm of STRTGY. The decision upon a strategy for the move is based upon the consideration of four factors, each of which are weighted in a "polynomial" fashion. These four terms of the polynomial are based upon:

1) SOUTH's concession point,
2) POINTS relative to SOUTH,
3) Previous experience, and
4) Economic conditions.

The coefficients assigned to each of these terms are inserted into the system at the start of the game, and may become modified as the game progresses, as discussed in the description of the analysis function.

Even before considering any of the four factors, the computer checks to ensure that it is not in danger of losing because of relative wealth or strength disadvantage. If it is, the system immediately selects as its strategy the one which will gain the most wealth or strength, as needed, and returns to the main program without considering any of the four factors. If the computer finds that this emergency action is necessary, later analysis of the move is not performed.

If emergency action is not necessary, each of the four factors are considered and used in determining a final strategy for the move.

The first factor to be considered is SOUTH's concession point. The computer first determines if it wants to call for a renegotiation. Renegotiation is requested if it finds that its opponent's proposal was to arm and that he is quite strong already; it requires SOUTH to submit a new concession point, although the new proposal may be the same as the original. The next step after considering (and possibly carrying out) renegotiation is to attempt to determine SOUTH's probable forthcoming strategy. The computer selects candidates for its opponent's

strategy based on weighted reliability estimates, patterns of dishonesty in SOUTH's proposals, history of previous games with this player, and formal game theory. After deciding upon SOUTH's probable strategy, the computer selects as the first term of the polynomial the strategy which maximizes NORTH's gain relative to SOUTH if SOUTH actually selects that strategy.

The second factor to be considered in selecting a strategy is based on NORTH's points relative to SOUTH. Depending upon whether the computer is behind, ahead, or even with its opponent, this term of the polynomial is set to the strategy which maximizes NORTH's possible gain or minimizes its possible loss. Formal game theory is used in selecting these possible strategies.

The third factor to be considered is the most difficult one, because it is based upon previous experience. If SOUTH has been a previous opponent (within the last ten opponents), there exists a history of his previous games in the computer's long term memory. NORTH can use this information in predicting SOUTH's probable moves. In addition, NORTH can search other strategy types contained in its libraries of past games in order to select previously successful strategies to use against its opponent. After several moves have been completed, the computer searches all the strategy listings in its "experience" in order to classify SOUTH's general pattern of strategies. Each of these listings may contain pointers to other strategy patterns which have proven successful against SOUTH's pattern in the past. NORTH can also pattern-match its own strategy pattern against those existing in the library in order to determine its own predicted move. The computer occasionally selects a

strategy opposite to the predicted one to avoid being stereotyped by SOUTH. This is called a "guess-opposite" selection of a strategy. It is the third factor of the polynomial which gains from the learning capabilities of the machine. The method of learning and pattern-matching is discussed in greater detail in a later section.

The fourth and final factor to be considered in selecting a strategy is based on an estimate of the economic condition in effect. After the completion of each move, the program analyzes the results to determine if they match the expected values. If not, it estimates the economic conditions and sets this term of the polynomial to the strategy which takes the most advantage of the state of the economy. For example, if prices are low, it is probably the best time to arm, but if prices are abnormally high it may be too expensive to arm at that time.

After all four factors have been considered in selecting a strategy, the system conducts a vote to determine the choice for the move. If SOUTH's concession point has not been declared, the coefficient of the first term is set to zero, and a tentative strategy is chosen based on the other three terms. When it becomes time for the reconsideration, the vote is taken of all four terms for deciding the final strategy. The vote is accomplished by summing the coefficients of the terms voting for each of the three possible strategies. The strategy which receives the greatest sum is the "winning" strategy; in case of a tie, the computer selects from the tieing strategies the one which will result in the greatest absolute point gain.

Having selected a strategy, control is returned to the main program which either calls upon Subroutine CPNDCN to decide NORTH's concession point, or else locks the strategy into the system awaiting SOUTH's indication of a strategy.

The third function of Subroutine STRTGY is that of analyzing the completed move in order to determine if a better strategy could have been chosen. The system does this by entering NORTH's relative payoff table with the actual strategy chosen by SOUTH to determine the strategy which provides the maximum relative gain. If the computer determines that the correct strategy was chosen, no adjustments are performed and control is returned to the main program. If, however, the best strategy was not picked by NORTH, the computer determines if any of the votes cast for the different strategies matched the best possible strategy. If any are found, the coefficients corresponding to those terms are then increased (tuned up), and those assigned to the wrong terms tuned down. If no votes are found, the analysis was unsuccessful for that move.

If the computer ultimately wins the game, the final values of the coefficients for each of the terms are inserted into the long-term memory of the player for use as the initial values in the succeeding game with that player. This is done because the system found these coefficients successful and they would probably provide a better base from which to start the next time. This is but another part of the learning process of the system.

Thus, Subroutine STRTGY attempts to determine a strategy to be followed in the game of DIPLOMAT in much the same way that a human reasons through the game. Similar to a human, if the reasoning process results in a wrong answer, the system attempts to improve itself.

2. Subroutine CPNDCN

This is the second of the program's subroutines which employs human-like reasoning. Its purpose is to determine a concession point to be proposed to SOUTH after having selected a tentative (or final) strategy. Figure 5 provides a macro-flowchart of this subroutine.

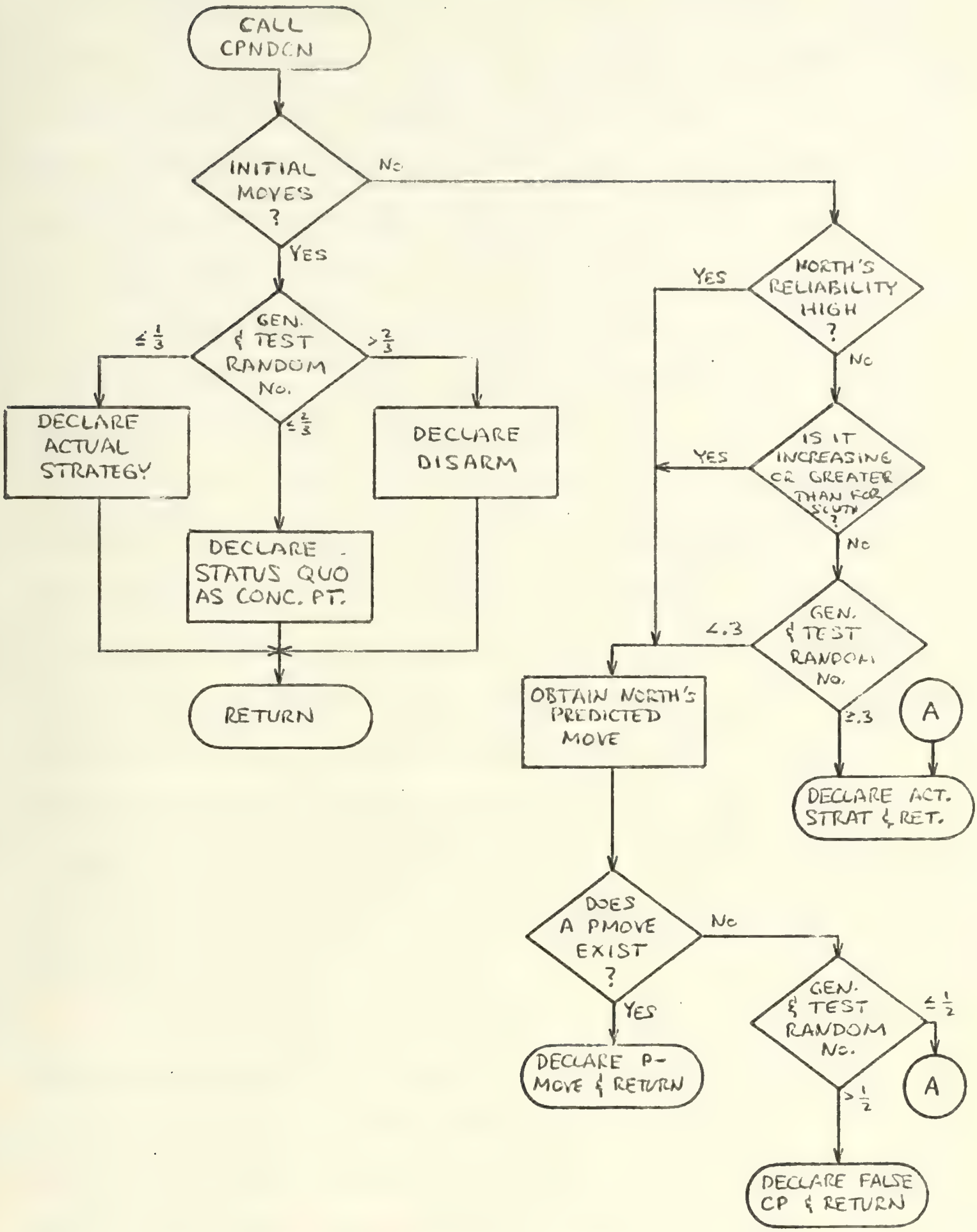


Figure 5. Basic Algorithm of CPNDCN

NORTH's concession point must be carefully chosen. In order to keep the player off guard, the computer must try to maintain at least a facade of reliability, yet not be so reliable as to be "read like a book." If NORTH and SOUTH are each following a pattern of moves, the computer should indicate that it expects to follow the pattern, even if it has no such intention.

For the initial moves, the computer uses a semi-random pattern of selecting proposals. Weight is given to choosing either the actual strategy proposed, or to choosing a passive (i.e., disarming or status quo) declaration. After the initial moves have been completed, however, the computer utilizes much of the data it has been accumulating on the player during the game. In addition to pattern-matching previous moves, the computer maintains estimates of the player's reliability as well as its own. EN is NORTH's estimate of SOUTH's honesty, and ES is what NORTH thinks SOUTH estimates for the computer's reliability. These are both weighted values, with the most weight given to the recent moves. EN and ES are calculated after each move by comparing the actual strategy with the concession point. The values of EN and ES drop accordingly each time there is not a match.

If ES is high, is increasing, or at least is greater than EN, the system determines its predicted move from pattern-matching its own strategies, and uses a predicted move as its concession point. If, on the other hand, NORTH's reliability needs improving, the subroutine normally selects the actual strategy determined by STRTGY as the computer's concession point.

As with STRTGY, CPNDCN was written based on hand simulation of the game. Notes were kept on the reasons behind each decision, and

used to help determine the methods of reasoning developed in these subroutines.

B. MEMORY STRUCTURE AND THE LEARNING PROCESS

The information within this section is somewhat more detailed because it describes the attempts to exemplify the concepts of Piaget in structuring the mind. Computer list-processing techniques are used in structuring and manipulating the memory for this task. The reason for this is that these techniques model the theoretical structures of the brain and are efficient in coding requirements.

1. The Memory Structure

The memory structure of the program, depicted in Appendix A, is divided into two segments, the "temporary" or short-term memory and the "permanent" or long-term memory. The short-term memory contains data regarding the current game and the long-term memory contains the data which comprises the experience gained from previous games.

The short-term memory is used to maintain data necessary for determining the pattern of play being used by both the human player and the computer. The information within this segment of memory grows as the game progresses. At the end of the game, pertinent data is summarized and transferred to the long-term memory, and the short-term memory is deleted or "forgotten." The temporary memory consists of arrays and lists for determining the reliability estimates used in the reasoning processes of the system. In addition, this segment of memory contains a pattern of strategies used by each participant. It also maintains a total of the number of times each strategy is selected. The former is used in generally classifying the method of play which is being employed,

and the latter is used in determining the overall aggressiveness being exhibited.

The long-term memory, the "experience," consists of arrays and lists arranged into four libraries. Libraries are interconnected as they are developed, in order to maintain continuity in the flow of information and facilitate access to specific data. These four libraries are labeled the "Catalogue of Players," the "Library of Initial Moves," the "Library of Types of Moves," and the "Library of Sequences of Moves." For simplicity these names are abbreviated the "Catalogue," the "Initial Library," the "Type Library," and the "Sequence Library."

To provide a basic understanding of the construction and maintenance of these libraries, it is necessary to define various terms associated with them. A move is a played strategy. Groups of three moves are categorized into five levels of aggressiveness. Groups are thus combinations of any three strategies played. The following example illustrates the construction of groups:

Suppose an opponent picked the following moves (strategies):

1 2 1 1 3 2 2 1 3 3 1 1 1 2 1 3

Group (1) then consists of 1 2 1, Group (2) is 2 1 1, Group (3) is 1 1 3, Group (4) is 1 3 2, and so on.

Patterns are determined in the Initial Library according to individual moves, and are determined in the Type Library by a sequence of groups. The sequence of groups is called a "TYPE." Further discussion will be given to the utilization of categories of aggressiveness, and their associated groups, in the explanation of the learning process of the program.

The Catalogue contains information on one to ten players. As a player is first introduced into the game, a unique set of nodes (sequential set of computer words) is established for him which at the end of the game will be filled with data and pointers regarding his history of play. The most recent player is maintained at the top of the catalogue and the oldest player at the bottom. As players participate in additional games, a reordering of the Catalogue is accomplished to maintain this perspective. If the Catalogue reaches its capacity of ten players and a new player is introduced into the system, the information on the oldest player is deleted (forgotten) and the new player established in the Catalogue.

Information maintained on each player includes pointers to the initial strategies and a sequence of "TYPE" patterns used by both the player and the computer in previous games. It also contains the set of parameters (the foundation of the coefficients considered in the strategy polynomial) which have proven most successful against that player, the average values of reliability demonstrated by both the player and the computer when playing against that player, and the player's aggressiveness in previous games.

The INIT Library contains the initial three moves (first group) used in various games in the past, and pointers to the Type Library. Information on the exact initial strategies used in previous games is maintained so that the computer can try to get a "jump" on the player at the beginning of the game. It is used to predict SOUTH's initial strategy and to aid the computer in selecting the best offense against this strategy.

The Type Library contains up to ten structures. A structure consists of a header cell followed by a TYPE of eight to ten groups. The header cell contains pointers to other structures in the Type Library which have demonstrated a successful defense against this TYPE, and against which this TYPE has proven to be a good offense.

The Sequence Library is a history of the TYPEs and associated initial strategies for each game played by a particular player in the Catalogue. It also contains the computer's TYPEs used against any player in the Catalogue. Each entry in the Sequence Library contains a pointer to a structure in the Type Library and a pointer to the initial strategy associated with that structure.

When the capacity of each of these libraries is filled, the oldest information is deleted, or updated, to make room for the new information. This conforms to the contention that the brain grows to a finite size, then information becomes restructured or forgotten as it grows out of date.

2. <u>The Learning Process</u>

The learning process progresses as the memory structures develop. During the first game the computer plays, there is nothing in long-term memory so the computer must reason through the game as best it can. During succeeding games, however, the computer searches long-term memory for strategy predictions and pattern-matching types of strategies.

When the player signs into the system at the start of a game, the computer searches the Catalogue to determine if this player has been played before. If so, the computer assumes that he will follow

the same initial strategy and determines the best moves against that strategy. After two moves the computer pattern-matches these against the INIT Library to find the closest match. The computer's third move is selected as the one which is best against the third move listed in the closest matched INIT group. After the third move, the computer again pattern-matches the initial three moves against the INIT Library, finds the closest match, and predicts that the player will use the TYPE to which that entry in the INIT Library points.

The Type Library provides general categories of strategies to simplify pattern-matching. In a twenty-move game, there could be an almost infinite number of sequences of exact strategies used, but by categorizing exact strategies into general classifications, pattern-matching may be done at a meta-level. These categories, as stated earlier, are determined by arranging the moves into groups of three and classifying the group into one of five levels of aggressiveness. Figures 6 and 7 illustrate the techniques of categorizing strategies and making predictions based on the types obtained. The overlap of the groups provides continuity in classifying and predicting.

As the game progresses, the computer pattern-matches the TYPEs used by both the player and the computer, which are maintained in short-term memory, against the Type Library. This provides NORTH with predicted moves for both participants, and also with an indication of the TYPE that is best to use against SOUTH's TYPE.

The Sequence Library provides the computer with the ability to make better predictions of the TYPEs that a player will use. After each game with a player, a pointer to the TYPE employed in that game is

CATEGORY	1	A1	2	A2	3
Combination of Groups of Three Moves	111	113	123	133	332
	112	131	132	331	323
	121	311	213	313	233
	211	122	231	322	333
		212	312	232	
		221	321	223	
			222		

The sum of the strategies for each category is:

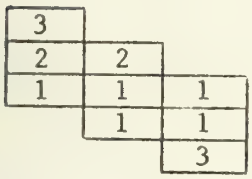
Category 1 - 3 or 4 Category A1 - 5

Category 2 - 6 Category A2 - 7

Category 3 - 8 or 9

Figure 6. Category Values of Strategies Used in Pattern-Matching

By totaling the first two moves of any predicted category, it is possible to predict the next move:



2 1 A1

Overlapping of Category Groups Shown Above

Example Strategies and Categories are Inserted

If First Two Moves Total:	For Category Number:	The Move Predicted Is:
2	1	2
3	1	1
2	A1	3
3	A1	2
4	A1	1
3	2	3
4	2	2
5	2	1
4	A2	3
5	A2	2
6	A2	1
5	3	3
6	3	2

Figure 7. Prediction of the Next Move Based on Strategy Type

inserted in the Sequence Library. The computer can pattern-match these lists to determine the expected type which the player will use during the next game.

At the end of a game, corresponding data between the short-term memory and the long-term memory are compared. This is accomplished by the same methods of pattern-matching used during the game. If similarity exists, the structures of the short-term memory are combined with the closest Initial and Type Library structures to form more up-to-date information. If no similarities exist, the information from temporary memory is transferred to permanent memory as new Initial and Type Library entries. If these libraries are at capacity, the oldest information is deleted (forgotten) and the new information is inserted.

As suggested by the theory, past experience is utilized to obtain the best prediction of events, but if the computer finds no matching experience upon which to draw, it must reason through the problem as best it can. Knowledge grows when new structures are formed or old ones reconstructed.

C. ANALYSIS OF THE GAME

After a rather poor start, the computer has gone ahead of its opponents in total points for all games, and the gap is widening. This is due partly to some minor changes in the strategy decision routines, however evidence indicates that most of the credit can be given to the building of the libraries. This contention is supported by the fact that the analysis portion of the strategy routine tends to increase (tune up) the basis of the coefficient assigned to the experience factor, and tune down some of the others.

Based on observation of the game and discussions with those playing it, it is evident that the players and the computer use many of the same factors in deciding upon a strategy and a concession point. In addition, concepts built by the human are similar to the concepts formed by the computer and stored within its memory. The average values for the reliability estimates that the computer maintains on both itself and its opponent remain relatively constant as the game progresses. The same is true of the weighted reliability.

IV. CONCLUSIONS

> "If a program can be constructed that, when placed in a prisoner's dilemma situation, exhibits behavior like the behavior of people when placed in the same situation, then that program will be a powerful tool for generalizations."

The above statement by Professor Weil is repeated from an earlier section of this thesis for emphasis. In its existing form, this program does provide a powerful tool for extracting generalizations regarding human behavior in a medium risk decision making task. With but minor changes in wording or by incorporating extensions to the game, the program can be made applicable to almost any field of corporate or governmental endeavor requiring a psychological understanding of human behavior in making decisions where different gains can be achieved at varying risks.

A. EXTENSIONS AND CHANGES

DIPLOMAT is in itself an extension to the classic prisoner's dilemma game. It may be extended or changed to broaden its applicability to real world situations and make the game considerably more interesting.

The simplest change to the program would be to change the name assigned to the three strategies. For example, the applicability of the program could be changed by transforming the words arm/status-quo/disarm into the words buy/wait/sell, or perhaps raise-prices/no-change/lower-prices.

The whole outcome of the game can be changed drastically by changing

the POINTS formula. This is done by simply assigning different coefficients to the factors of WEALTH and STRENGTH, or by changing the values in Table I (the wealth changes for the various strategies shown as a function of player strength). Thus the game may be altered to match actual conditions encountered in, say, the business community.

The number of strategies from which to choose could be changed in either direction. Decreasing the choice to two would render the game closer to the prisoner's dilemma situation, but even this has many applications in the real world. On the other hand, it would be more interesting to increase the number of strategies. For example, there could be two levels of arming and two levels of disarming, or for buying or selling. Some implications of increasing the number of strategies, however, would be that the pattern-matching routines may not be feasible in their present state. It would probably require a pattern-matching scheme which placed more emphasis on the meta-level, i.e., looking at the broad spectrum of the pattern from a higher level, rather than pattern-matching individual strategies or small groups of strategies.

Increasing the number of players is probably the most difficult of the possible extensions to the game, but provides the most interesting possibilities. If the number of players is increased, treaties between the players and alliances among groups of players may be proposed and formed. An infinite number of situations may arise out of this idea, for example, one nation might wonder whether his ally will abide by the alliance or possibly turn on him several moves hence; or, a player might hesitate to sign an agreement when a better one might be offered from a different player. In the diplomacy situation, several nations may disarm to gain wealth, then form an alliance against a stronger nation which

has armed to gain strength at the cost of wealth. Increasing the number of players would also make the concepts of reasoning and learning more difficult, but more fascinating. For example, will one nation risk an alliance with another when it remembers prior treachery? Instead of merely analyzing what one's opponent thinks of him, a player will have to analyze several players' estimates of all the opponents. The reliability considerations become almost overwhelming.

B. POSSIBLE USES OF DIPLOMAT

It is considered that Professor Weil was correct in assuming that the prisoner's dilemma computer game would be a powerful tool for generalizations. The game of DIPLOMAT or its extensions would be an invaluable aid in the training of executives prior to stepping into positions requiring the art and finesse of personal contact. The speed of the computer permits the game to proceed rapidly and permits many different situations to be established by changing payoffs and formulas. The performance of different players against standard setups could then be analyzed.

In addition, personnel in the study of behavioral science and psychology could develop a better understanding of the nature of the human decision-making process and of the risk of striking out on an independent path as opposed to the benefits and security gained by cooperating. The fact that the risky path may lead to greater gains may be more important to some people than to others.

The training of college students in the theory of marketing and analysis would also be enhanced by applying textbook concepts to the difficulties of the everchanging conditions and types of people with

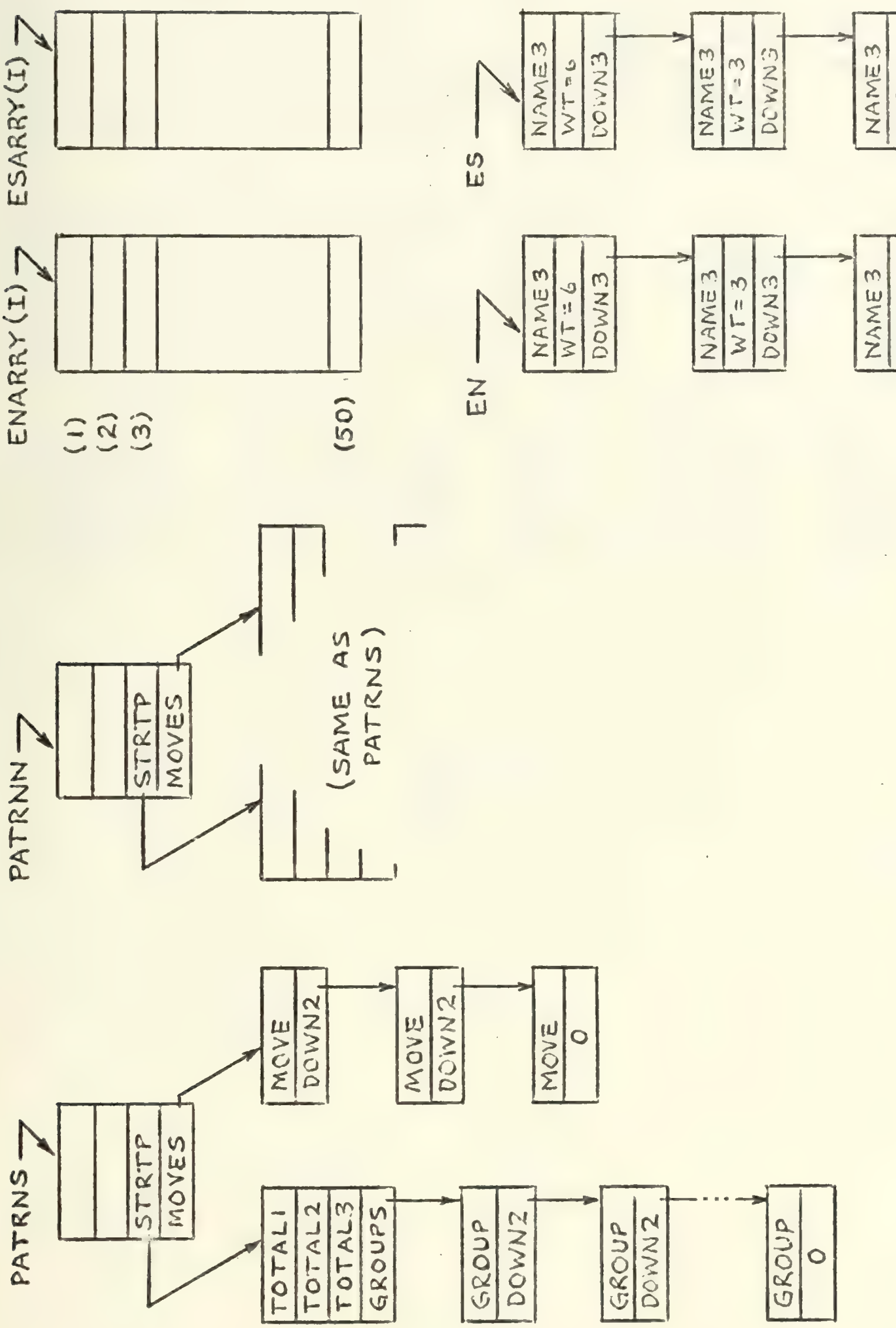
which they may deal. This training might prove useful for young officers in the diplomatic corps or even at junior level armed forces colleges.

In order to enhance the development of computer application to this type of work, it is recommended that consideration be given to the possibility of adapting this program to marketing or financial decision-making courses in the managem nt curriculum. This type of program could be extremely useful as a tool in teaching management students the power and usefulness of the computer. It demonstrates the interface capabilities of man and machine. It can also be used as a teaching aid in artificial intelligence, game theory, and basic management-decision courses. The first part of Section III describing the game could be reproduced for use as a handout for potential players.

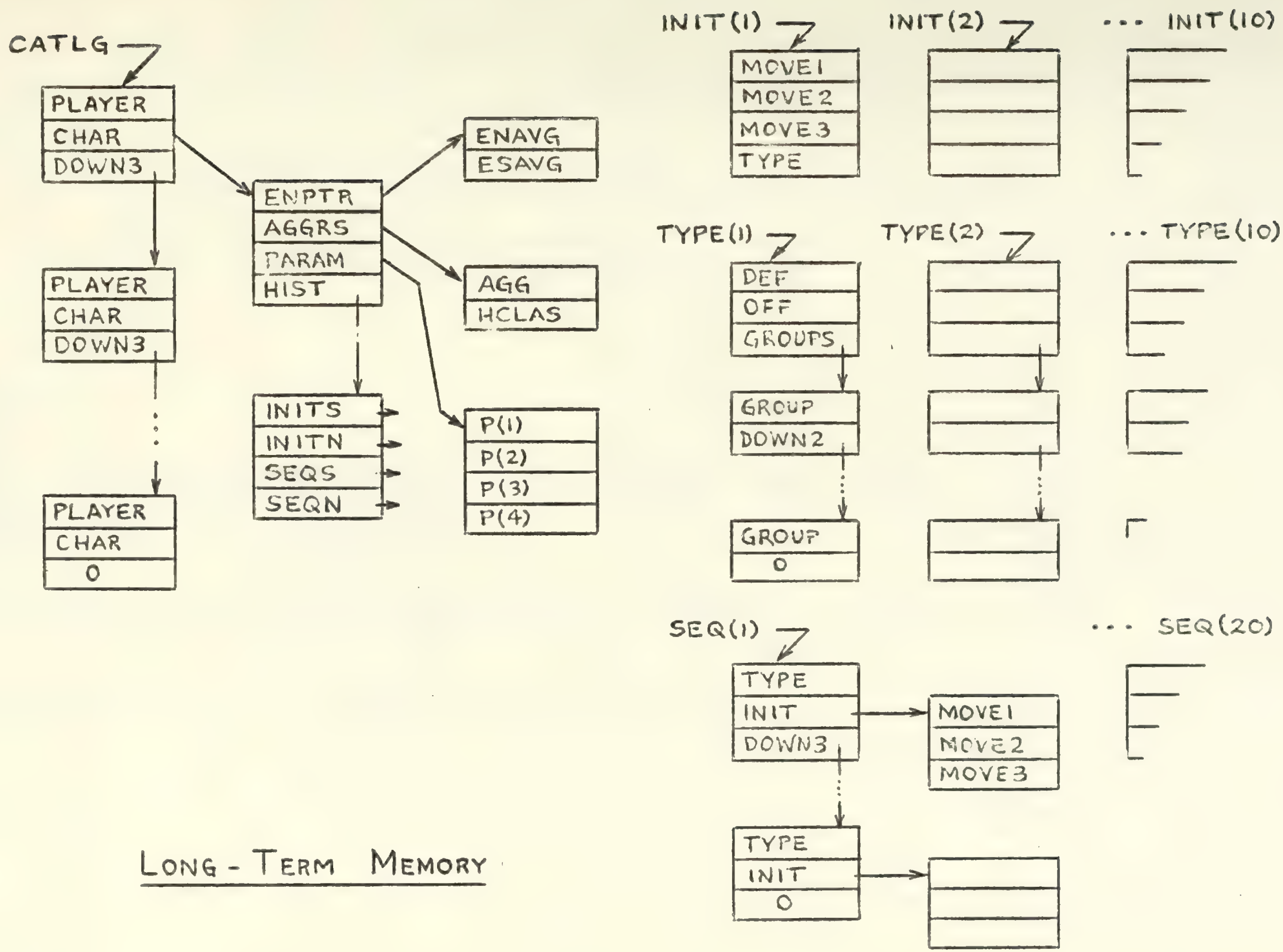
The concept and performance of DIPLOMAT appears to be good. It is ahead of the human players in POINTS and performs well in adapting to different human strategies that have been tried against it. However, similar to a human, it does not win every game, indicating that even it has more to learn.

APPENDIX A

THE MEMORY STRUCTURE OF DIPLOMAT



SHORT-TERM MEMORY



LONG - TERM MEMORY

APPENDIX B
EXAMPLE COMPUTER TERMINAL OUTPUT

```
   DO YOU WISH TO READ MEMORY AND REBUILD THE HISTORY OF PLAYERS, YES OR NO "A3" FORMAT.
YES

THIS PROGRAM REQUIRES THE FOLLOWING INPUTS:
     1.  YOUR NAME IN A4 FORMAT, RIGHT JUSTIFIED IF LESS THAN FOUR
         CHARACTERS IN LENGTH.
     2.  INRAND, AN ODD INTEGER OF NINE OR LESS DIGITS, OR RANDOM ORIGIN,
         FOR USE IN GENERATING RANDOM NUMBERS.

YOUR NAME:
 JIM

INRAND:
555

A TOSS OF A COIN WILL BE USED TO DETERMINE WHO GOES FIRST.
YOU MAY CALL HEAD OR TAIL:
HEAD

SORRY YOU  LOST THE TOSS OF THE COIN.
THEREFORE I WILL MAKE THE FIRST PROPOSAL (CONCESSION POINT).


PARAMETERS AT START OF GAME ARE:  10    10   10   20
```

```
MY PROPOSAL (CONCESSION POINT) WHERE 1=ARM, 2=MAINTAIN THE STATUS QUO, AND 3=DISARM IS: 2.


THE APPROXIMARE PAYOFF MATRIX FOR THE EXISTING CONDITIONS OF STRENGTH AND WEALTH IS SHOWN BELOW.
   INDICATED PAYOFFS ARE TO SOUTH (YOU).


                         SOUTH
     STRATEGY         1     2     3
                  *********************
                  *
       N   1      *  -1     1     2
       O          *
       R   2      *  -1     0     1
       T          *
       H   3      *   2    -1     2


WHAT IS YOUR PROPOSAL, STRATEGY 1(ARM), 2(MAINTAIN THE STATUS QUO), OR 3(DISARM): ?
3

IT IS NOW TIME TO CARRY OUT THE STRATEGY OF EACH SIDE.
THE COMPUTER'S MOVE IS LOCKED INTO THE SYSTEM.
PLEASE INDICATE YOUR STRATEGY AS 1, 2, OR 3:
3
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  1
    SOUTH(PLAYER):    3


THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                    WEALTH      STRENGTH      *POINTS*
COMPUTER(NORTH) *      -1   *       1     *       7    *
PLAYER(SOUTH)   *       5   *      -1     *       5    *
```

```
IT IS NOW MOVE NUMBER  2.  IT IS YOUR TURN TO GO FIRST.

THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE LAST MOVE.
YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY AND CP.

WHAT IS YOUR PROPOSAL, STRATEGY 1(ARM), 2(MAINTAIN THE STATUS QUO), OR 3(DISARM) ?
3
MY PROPOSAL (CONCESSION POINT) WHERE 1=ARM, 2=MAINTAIN THE STATUS QUO, AND 3=DISARM IS: 1.

NOTE THAT MY CP IS TO ARM.
PLEASE INDICATE WITH A "YES" OR "NO" (RIGHT JUSTIFIED IN A3 FORMAT) IF YOU WISH TO RENEGOTIATE:
 NO

IT IS NOW TIME TO CARRY OUT THE STRATEGY OF EACH SIDE.
THE COMPUTER'S MOVE IS LOCKED INTO THE SYSTEM.
PLEASE INDICATE YOUR STRATEGY AS 1, 2, OR 3:
1
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  1
    SOUTH(PLAYER):    1

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                    WEALTH     STRENGTH      *POINTS*
COMPUTER (NORTH) *     -2   *         2    *        9   *
PLAYER (SOUTH)   *      4   *         0    *        7   *
```

```
IT IS NOW MOVE NUMBER  3.  IT IS MY TURN TO GO FIRST.

MY CP IS: 2.

THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE LAST MOVE.
YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY  AND CP.

WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
2
WHAT IS YOUR STRATEGY ?
2
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  1
    SOUTH(PLAYER):    2

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                   WEALTH     STRENGTH     *POINTS*
COMPUTER (NORTH) *    -6   *      3    *       6   *
PLAYER (SOUTH)   *     7   *      0    *      13   *
```

```
IT IS NOW MOVE NUMBER  4.  IT IS YOUR TURN TO GO  FIRST.

THE APPROXIMATE PAYOFF MATRIX FOR THE EXISTING CONDITIONS OF STRENGTH AND WEALTH IS SHOWN BELOW.
   INDICATED PAYOFFS ARE TO SOUTH (YOU).

                                    SOUTH
     STRATEGY                 1       2       3
                          ******************
                          *
       N    1             *   1       3       4
       O                  *
       R    2             *   1       2       3
       T                  *
       H    3             *   4       1       4


WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
3
MY CP IS: 2.

WHAT IS YOUR STRATEGY ?
1
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
     NORTH(COMPUTER):  1
     SOUTH(PLAYER):    1

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                       WEALTH      STRENGTH      *POINTS*
COMPUTER (NORTH) *      -11   *        4     *       0    *
PLAYER (SOUTH)   *        5   *        1     *      13    *
```

```
IT IS NOW MOVE NUMBER  5.  IT IS MY TURN TO GO FIRST.

MY CP IS: 3.

THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE LAST MOVE.
YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY  AND CP.

WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
 2
WHAT IS YOUR STRATEGY ?
 1
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  3
    SOUTH(PLAYER):    1

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                      WEALTH      STRENGTH      *POINTS*
COMPUTER (NORTH) *      -9    *       3     *      -1    *
PLAYER (SOUTH)   *       2    *       2     *      16    *
```

```
IT IS NOW MOVE NUMBER  6.  IT IS YOUR TURN TO GO  FIRST.

THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE LAST MOVE.
YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY  AND CP.

WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
2
MY CP IS: 3.

WHAT IS YOUR STRATEGY ?
3
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  3
    SOUTH(PLAYER):    3

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                      WEALTH       STRENGTH      *POINTS*
COMPUTER (NORTH) *      -7    *        2     *       0    *
PLAYER (SOUTH)   *       3    *        1     *      15    *
```

```
IT IS NOW MOVE NUMBER  7.  IT IS MY TURN TO GO FIRST.

MY CP IS: 2.

THE APPROXIMATE PAYOFF MATRIX FOR THE EXISTING CONDITIONS OF STRENGTH AND WEALTH IS SHOWN BELOW.
  INDICATED PAYOFFS ARE TO SOUTH (YOU).

                           SOUTH
    STRATEGY          1      2      3
                  *******************
                  *
      N   1       *  -1      1      2
      O           *
      R   2       *  -1      0      1
      T           *
      H   3       *   2     -1      2


WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?

2
WHAT IS YOUR STRATEGY ?
1
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  3
    SOUTH(PLAYER):    1

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                      WEALTH       STRENGTH       *POINTS*
COMPUTER (NORTH) *      -5    *        1     *       -1    *
PLAYER (SOUTH)   *      -1    *        2     *       16    *
```

```
IT IS NOW MOVE NUMBER  8.  IT IS YOUR TURN TO GO  FIRST.

THE APPROXIMATE PAYOFF MATRIX FOR THE EXISTING CONDITIONS OF STRENGTH AND WEALTH IS SHOWN BELOW.
  INDICATED PAYOFFS ARE TO SOUTH (YOU).

                           SOUTH
    STRATEGY          1       2       3
                 *******************
                 *
     N   1       *    1       3       4
     O           *
     R   2       *    1       2       3
     T           *
     H   3       *    4       1       4


WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
1
MY CP IS: 2.

WHAT IS YOUR STRATEGY ?
2
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):   3
    SOUTH(PLAYER):     2

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                      WEALTH     STRENGTH     *POINTS*
COMPUTER (NORTH) *      -3   *       0    *      -2    *
PLAYER (SOUTH)   *      -2   *       2    *      14    *
```

```
IT IS NOW MOVE NUMBER  9.  IT IS MY TURN TO GO FIRST.

MY CP IS: 1.

NOTE THAT MY CP IS TO ARM.
PLEASE INDICATE WITH  A "YES" OR "NO" (RIGHT JUSTIFIED IN A3 FORMAT) IF YOU WISH TO RENEGOTIATE:

YES
BASED ON YOUR REQUEST FOR RENEGOTIATION, I HAVE CONSIDERED MY CONCESSION POINT. MY NEW CP IS TO: 2.

THE APPROXIMATE PAYOFF MATRIX FOR THE EXISTING CONDITIONS OF STRENGTH AND WEALTH IS SHOWN BELOW.
   INDICATED PAYOFFS ARE TO SOUTH (YOU).

                              SOUTH
    STRATEGY             1      2      3
                   *******************
                   *
      N    1       *  -3     -1      0
      O            *
      R    2       *  -3     -2     -1
      T            *
      H    3       *   0     -3      0


WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
3
WHAT IS YOUR STRATEGY ?
3
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
     NORTH(COMPUTER):   3
     SOUTH(PLAYER):     3

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:
                       WEALTH      STRENGTH      *POINTS*
COMPUTER (NORTH) *       0    *       -1    *       1    *
PLAYER (SOUTH)   *       0    *        1    *      15    *
```

```
IT IS NOW MOVE NUMBER 10.  IT IS YOUR TURN TO GO  FIRST.

THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE LAST MOVE.
YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY  AND CP.

WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
3
MY CP IS: 3.

WHAT IS YOUR STRATEGY ?
2
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  3
    SOUTH(PLAYER):    2

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                      WEALTH     STRENGTH      *POINTS*
COMPUTER (NORTH) *       3   *       -2    *       2   *
PLAYER (SOUTH)   *       0   *        1    *      15   *
```

```
IT IS NOW MOVE NUMBER 11.  IT IS MY TURN TO GO FIRST.

MY CP IS: 2.

THE APPROXIMATE PAYOFF MATRIX FOR THE EXISTING CONDITIONS OF STRENGTH AND WEALTH IS SHOWN BELOW.
  INDICATED PAYOFFS ARE TO SOUTH (YOU).
                              SOUTH
    STRATEGY             1      2      3
                   *******************
                   *
      N   1        *  -1      1      2
      O            *
      R   2        *  -1      0      1
      T            *
      H   3        *   2     -1      2


WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
3
WHAT IS YOUR STRATEGY ?
3
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  3
    SOUTH(PLAYER):    3

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:
                    WEALTH      STRENGTH     *POINTS*
COMPUTER (NORTH) *     5    *      -3     *      3    *
PLAYER (SOUTH)   *     3    *       0     *     18    *
```

```
IT IS NCW MOVE NUMBER 12.  IT IS YOUR TURN TO GO  FIRST.

THE APPROXIMATE PAYOFF MATRIX FOR THE EXISTING CONDITIONS OF STRENGTH AND WEALTH IS SHOWN BELOW.
  INDICATED PAYOFFS ARE TO SOUTH (YOU).

                          SOUTH
   STRATEGY           1     2     3
                ******************
                *
     N   1      *  -3    -1     0
     O          *
     R   2      *  -3    -2    -1
     T          *
     H   3      *   4     1     4


WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
3
MY CP IS: 2.

WHAT IS YOUR STRATEGY ?
1
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
   NORTH(COMPUTER):   3
   SOUTH(PLAYER):     1

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                    WEALTH      STRENGTH      *POINTS*
COMPUTER (NORTH) *     7   *       -4      *      2    *
PLAYER (SOUTH)   *     0   *        1      *     21    *
```

```
IT IS NOW MOVE NUMBER 13.  IT IS MY TURN TO GO FIRST.

MY CP IS: 2.

THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE LAST MOVE.
YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY  AND CP.

WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
2
WHAT IS YOUR STRATEGY ?
3
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  3
    SOUTH(PLAYER):    3

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                     WEALTH      STRENGTH      *POINTS*
COMPUTER (NORTH) *      9    *      -5     *       3    *
PLAYER (SOUTH)   *      3    *       0     *      24    *
```

```
IT IS NOW MOVE NUMBER 14.  IT IS YOUR TURN TO GO  FIRST.

THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE LAST MOVE.
YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY  AND CP.

WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?

3
MY CP IS: 2.

WHAT IS YOUR STRATEGY ?
2
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  2
    SOUTH(PLAYER):    2

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                      WEALTH    STRENGTH     *POINTS*
COMPUTER (NORTH) *      13   *      -5    *     11    *
PLAYER (SOUTH)   *       3   *       0    *     24    *
```

```
IT IS NOW MOVE NUMBER 15.  IT IS MY TURN TO GO FIRST.

MY CP IS: 3.

THE APPROXIMATE PAYOFF MATRIX FOR THE EXISTING CONDITIONS OF STRENGTH AND WEALTH IS SHOWN BELOW.
  INDICATED PAYOFFS ARE TO SOUTH (YOU).

                          SOUTH
    STRATEGY          1     2     3
                   *******************
                   *
      N   1        *  -5    -3    -2
      O            *
      R   2        *  -3    -2    -1
      T            *
      H   3        *   4     1     4


WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
3
WHAT IS YOUR STRATEGY ?
3
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  1
    SOUTH(PLAYER):    3

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                     WEALTH      STRENGTH      *POINTS*
COMPUTER (NORTH) *     13    *      -4     *      20    *
PLAYER (SOUTH)   *      7    *      -1     *      27    *
```

```
IT IS NOW MOVE NUMBER 16.  IT IS YOUR TURN TO GO  FIRST.

THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE LAST MOVE.
YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY  AND CP.

WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
1
MY CP IS: 1.

NOTE THAT MY CP IS TO ARM.
PLEASE INDICATE WITH  A "YES" OR "NO" (RIGHT JUSTIFIED IN A3 FORMAT) IF YOU WISH TO RENEGOTIATE:

YES
BASED ON YOUR REQUEST FOR RENEGOTIATION, I HAVE CONSIDERED MY CONCESSION POINT. MY NEW CP IS TO: 2

WHAT IS YOUR STRATEGY ?
2
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):   2
    SOUTH(PLAYER):     2

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                     WEALTH      STRENGTH      *POINTS*
COMPUTER (NORTH) *     16    *      -4     *      26    *
PLAYER (SOUTH)   *      6    *      -1     *      25    *
```

```
IT IS NCW MOVE NUMBER 17.  IT IS MY TURN TO GO FIRST.

MY CP IS: 2.

THE APPROXIMATE PAYOFF MATRIX FOR THE EXISTING CONDITIONS OF STRENGTH AND WEALTH IS SHOWN BELOW.
   INDICATED PAYOFFS ARE TO SOUTH (YOU).

                              SOUTH
    STRATEGY             1      2      3
                   ******************
                   *
      N    1       *  -3     -1      0
      O            *
      R    2       *  -3     -2     -1
      T            *
      H    3       *   4      1      4


WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
1
WHAT IS YOUR STRATEGY ?
1
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  1
    SOUTH(PLAYER):    1

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                    WEALTH     STRENGTH     *POINTS*
COMPUTER (NORTH) *     16   *      -3    *      30   *
PLAYER (SOUTH)   *      2   *       0    *      21   *
```

```
IT IS NOW MOVE NUMBER 18.  IT IS YOUR TURN TO GO  FIRST.

THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE LAST MOVE.
YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY  AND CP.

WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
1
MY CP IS: 2.

WHAT IS YOUR STRATEGY ?
3
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
     NORTH(COMPUTER):   2
     SOUTH(PLAYER):     3

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:
                        WEALTH      STRENGTH      *POINTS*
COMPUTER (NORTH) *        17    *      -3     *      32    *
PLAYER (SOUTH)   *         6    *      -1     *      24    *
```

```
IT IS NOW MOVE NUMBER 19.  IT IS MY TURN TO GO FIRST.

MY CP IS: 2.

THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE LAST MOVE.
YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY  AND CP.

WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
3
WHAT IS YOUR STRATEGY ?
1
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  1
    SOUTH(PLAYER):    1

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                   WEALTH     STRENGTH     *POINTS*
COMPUTER (NORTH) *   15   *     -2     *     32   *
PLAYER (SOUTH)   *    4   *      0     *     24   *
```

```
IT IS NOW MOVE NUMBER 20.  IT IS YOUR TURN TO GO  FIRST.

THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE LAST MOVE.
YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY  AND CP.

WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
 2
MY CP IS: 2.

WHAT IS YOUR STRATEGY ?
 1
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  2
    SOUTH(PLAYER):    1

THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:

                     WEALTH     STRENGTH     *POINTS*
COMPUTER (NORTH) *     16   *      -2    *      34   *
PLAYER (SOUTH)   *      2   *       1    *      25   *
```

```
 IT IS NOW MOVE NUMBER 21. IT IS MY TURN TO GO FIRST.

MY CP IS: 2.

THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE LAST MOVE.
YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY AND CP.

WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?
2
WHAT IS YOUR STRATEGY ?
3
THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS FOLLOWS:
    NORTH(COMPUTER):  3
    SOUTH(PLAYER):    3

*** BY A RANDOM SELECTION, THE UMPIRE HAS DECIDED TO END THIS GAME AFTER 21 MOVES.
THE PARTICIPANT WITH THE MOST POINTS (POINTS = (2*WEALTH)+(5*STRENGTH)) IS DECLARED THE WINNER.

THE FINAL GRAND TOTALS FOR THIS GAME ARE:

                    WEALTH    STRENGTH     *POINTS*
                 *          *            *          *
COMPUTER(NORTH)  *      18  *       -3   *      35  *
PLAYER(SOUTH)    *       6  *        0   *      30  *
                 *          *            *          *

THE COMPUTER WON THE GAME.    THANK YOU FOR PLAYING.

PARAMETERS AT END OF GAME ARE:    14     6      16      4
```

APPENDIX C

COMPUTER PROGRAM LISTING

```
C
C     ***********************************************************
C     *                                                         *
C     * THE MAIN PROGRAM CONTROLS THE OPERATION OF THE GAME OF *
C     * DIPLOMAT.  IT IS SUPPORTED IN THIS TASK BY THE SEVEN   *
C     *       SUBROUTINES LISTED WITHIN THIS SECTION.           *
C     *                                                         *
C     ***********************************************************
C
      IMPLICIT INTEGER (A-W)
      COMMON/TDJE/APN,APS,STACK(40)
      COMMON/PAR/P(4),S(4),PRBLS(5)
      COMMON/EEE/EN,ES,TOPEN,TOPES
      COMMON/ENP/ENARRY(50),ESARRY(50)
      COMMON/CLS/DEFES,BDFFS,OFFEN,BOFFN,PMOVEN,PMOVES
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,FFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,FCNXN,FCNXS,PN,PS,FACTXN,FACTXS
      COMMON/ST/STRUE,LASTGO,NFLAG,TURN,ANAL,RECON
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP2/STK(10),STKM(10),STKN(10),STKNM(10)
      COMMON/TDP9/TYPENU,TYPE1,TYSOU,TYNOR
      COMMON/TDP8/RLHIST,NAHIST
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/TDP4/SEQ(20),SCONTR
      COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CONTR
      DIMENSION COMPN(3,3)
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DATA HEADS/'HEAD'/,TAILS/'TAIL'/,YES/'YES'/,NO/' NO'/
      DATA A1/'A1'/,A2/'A2'/
C
      APN=0
      APS=0
      CATLGN=0
      NC=1
      SCONTR=0
      INCNT=0
      INCNTR=10
      CONTR=0
      DO 180 I=1,4
      PRBLS(I)=0
  180 S(I)=0
      PRBLS(5)=0
```

```
      FACTXN=0
      FACTXS=0
      VALUE(1,1)=0
      VALUE(2,1)=0
      VALUE(3,1)=-1
      VALUE(4,1)=-2
      VALUE(5,1)=-3
      VALUE(6,1)=-4
      VALUE(7,1)=-6
      VALUE(1,2)=3
      VALUE(2,2)=2
      VALUE(3,2)=2
      VALUE(4,2)=1
      VALUE(5,2)=0
      VALUE(6,2)=-2
      VALUE(7,2)=-3
      VALUE(1,3)=3
      VALUE(2,3)=3
      VALUE(3,3)=3
      VALUE(4,3)=4
      VALUE(5,3)=3
      VALUE(6,3)=3
      VALUE(7,3)=2
C     (INITIALIZING ROUTINE)
      CALL INITL
      CALL ECALC(ENACT,ESACT)
      CALL REMEMB(INCNT,INCNTR)
C
C     (INPUTS)
C
      WRITE (6,399)
  399 FORMAT (//,' THIS PROGRAM REQUIRES THE FOLLOWING INPUTS:',/,5X,
     1'1.  YOUR NAME IN AN A4 FORMAT, RIGHT JUSTIFIED IF LESS THAN FOUR
     2CHARACTERS IN LENGTH.',/,5X,'2.  INRAND, AN ODD INTEGER OF NINE OR
     3 LESS DIGITS, OF RANDOM ORIGIN, FOR USE IN GENERATING RANDOM NUMBE
     4RS.')
 6001 WRITE (6,3991)
 3991 FORMAT (//,' YOUR NAME ?')
      READ (5,204,END=6000) PLAYER
      WRITE (6,3992)
 3992 FORMAT (/,' INRAND = ?')
      READ (5,3993) INRAND
 3993 FORMAT (I9)
C
      SN=0
      SS=0
      WN=0
      WS=0
```

```
      RS=0
      RW=0
      PN=0
      PS=0
      TYPENU=0
      TYPE1=0
      TYSOU=0
      TYNOR=0
      ECNXN=0
      ECNXS=0
      ANAL=0
      RECON=-10
      ISN=4
      ISS=4
      ENAVG=0
      ESAVG=0
      LASTGO=0
      EFLAG=0
      NFLAG=0
      WHOCAL=0
      NC=1
      PCNT=0
      PCNTM=0
      PCNTN=0
      PCNTNM=0
      TOPL1=0
      TOPL2=0
      TOPL1N=0
      TOPL2N=0
      PCOUNT=0
      MOV=0
      CALL TABCHG
      CALL CATLOG
      CALL PATRN
C
C     THE PROGRAM NOW DETERMINES WHO MAKES THE FIRST MOVE. SELECTION IS
C     BY A RANDOM PROCESS.
C
C     TURN=+1 INDICATES THAT THE PLAYER MAKES THE FIRST PROPOSAL.
C     TURN=-1 INDICATES THAT THE COMPUTER MAKES THE FIRST PROPOSAL.
C
      I=HEADS
      CALL RANDOM
      IF (YRAND.GE.0.5) I=TAILS
      WRITE (6,203)
  203 FORMAT (/,' A TOSS OF A COIN WILL BE USED TO DETERMINE WHO GOES
     1FIRST. YOU MAY CALL "HEAD" OR "TAIL":')
      READ (5,204) J
```

```
  204 FORMAT (A4)
      IF (J.NE.I) GO TO 250
C
      WRITE (6,205)
 205  FORMAT (//,' CONGRATULATIONS, YOU WON THE TOSS OF THE COIN.  YOU
     1MAY MAKE THE FIRST PROPOSAL (CONCESSION POINT).')
      GO TO 200
C
 201  WRITE (6,202) NC
 202  FORMAT (//,' IT IS NOW MOVE NUMBER',I3,'.  IT IS YOUR TURN TO GO
     1FIRST.')
 200  TURN=1
      IF (NC.EQ.1) GO TO 2006
      DO 2007 I=1,3
      DO 2007 J=1,3
      IF (RTABN(I,J).NE.COMPN(I,J)) GO TO 2006
 2007 CONTINUE
      GO TO 2008
 2006 WRITE (6,2000) ((RTABS(I,J),J=1,3),I=1,3)
 2000 FORMAT (//,' THE APPROXIMATE PAYOFF MATRIX FOR THE EXISTING CONDIT
     1IONS OF STRENGTH AND WEALTH IS SHOWN BELOW.',/,'    INDICATED PAYOF
     2FS ARE TO SOUTH (YOU).',//,T28,'SOUTH',/,T6,'STRATEGY',10X,'1',5X,
     3'2',5X,'3',/,19X,'********************',/,19X,'*',/,7X,'N',3X,
     4'1',7X,'*',I4,2I6,/,7X,'O',11X,'*',/,7X,'R',3X,'2',7X,'*',I4,2I6,
     5/,7X,'T',11X,'*',/,7X,'H',3X,'3',7X,'*',I4,2I6,///)
      GO TO 2010
 2008 WRITE (6,2009)
 2009 FORMAT (//,' THE APPROXIMATE PAYOFF MATRIX IS UNCHANGED FROM THE L
     1AST MOVE.',/,' YOU MAY USE IT AS AN AID IN DECIDING YOUR STRATEGY
     2 AND CP.',//)
 2010 IF (NC.GT.2) GO TO 2002
      WRITE (6,2001)
 2001 FORMAT (' WHAT IS YOUR PROPOSAL, STRATEGY 1(ARM), 2(MAINTAIN THE S
     1TATUS QUO), OR 3(DISARM) ?')
      GO TO 2005
 2002 WRITE (6,2003)
 2003 FORMAT (' WHAT IS YOUR PROPOSAL, (1,2,OR 3) ?')
C
 2005 READ (5,206) CPS
  206 FORMAT (I1)
      IF (CPS.NE.1.AND.CPS.NE.2.AND.CPS.NE.3) GO TO 410
C
C       (SINCE CPS HAS BEEN DECLARED, THE SYSTEM MAY DECIDE ITS
C         STRATN AND CPN NOW, WITHOUT FURTHER RECONSIDERATION.)
      CALL STRTGY(MOV,INCNT,PCNT,PCNTM,INCNTR,PCNTN,PCNTNM)
      CALL CPNDCN(MOV,INCNT,PCNTN,PCNTNM,INCNTR)
C
      IF (NC.GT.2) GO TO 2061
```

```
      WRITE (6,207) CPN
      GO TO 2065
 2061 WRITE (6,2062) CPN
 2062 FORMAT (//,' MY CP IS:',I2,'.')
C        (DETERMINE IF SOUTH WANTS TO RENEGOTIATE:)
 2065 IF (CPN.GT.1) GO TO 300
      WRITE (6,2071)
 2071 FORMAT (/,' NOTE THAT MY CP IS TO ARM.',/,' PLEASE INDICATE WITH
     1A "YES" OR "NO" (RIGHT JUSTIFIED IN A3 FORMAT) IF YOU WISH TO RENE
     2GOTIATE:')
    3 READ (5,2072) I
 2072 FORMAT (A3)
      IF (I.EQ.NO) GO TO 300
      WHOCAL=1
      CALL RENEG(PROBLM,WHOCAL)
      GO TO 300
C
  250 WRITE (6,251)
  251 FORMAT (/,' SORRY, YOU LOST THE TOSS OF THE COIN, THEREFORE I WILL
     1 MAKE THE FIRST PROPOSAL (CONCESSION POINT).')
      GO TO 252
C
 255  WRITE (6,256) NC
 256  FORMAT (//,' IT IS NOW MOVE NUMBER',I3,'.  IT IS MY TURN TO GO FIR
     1ST.')
 252  TURN=-1
C
C     THE PROGRAM NOW DECIDES UPON A STRATEGY, BUT THE STRATEGY MAY BE
C     CHANGED IN LIGHT OF SOUTH CONCESSION POINT AFTER IT IS DECLARED.
C
      CALL STRTGY(MOV,INCNT,PCNT,PCNTM,INCNTR,PCNTN,PCNTNM)
C
C     HAVING DECIDED UPON A TENTATIVE STRATEGY, THE SYSTEM NOW
C     DETERMINES THE COMPUTERS CONCESSION POINT.
C
      CALL CPNDCN(MOV,INCNT,PCNTN,PCNTNM,INCNTR)
C
      IF (NC.GT.2) GO TO 2075
      WRITE (6,207) CPN
 207  FORMAT (//,' MY PROPOSAL (CONCESSION POINT) WHERE 1=ARM, 2=MAINTAI
     1N THE STATUS QUO, AND 3=DISARM IS:',I2,'.')
      GO TO 2079
 2075 WRITE (6,2076) CPN
 2076 FORMAT (//,' MY CP IS:',I2,'.')
C
C        (DETERMINE IF SOUTH WANTS TO RENEGOTIATE:)
 2079 IF (CPN.GT.1) GO TO 2089
      WRITE (6,2071)
```

```
    4  READ (5,2072) I
       IF (I.EQ.NO) GO TO 2089
       WHOCAL=1
       CALL RENEG(PROBLM,WHOCAL)
C        (NOW ASK FOR SOUTH'S CONCESSION POINT.)
 2089  IF (NC.EQ.1) GO TO 208
       DO 2081 I=1,3
       DO 2081 J=1,3
       IF (RTABN(I,J).NE.COMPN(I,J)) GO TO 208
 2081  CONTINUE
       WRITE (6,2009)
       GO TO 2084
  208  WRITE (6,2000) ((RTABS(I,J),J=1,3),I=1,3)
 2084  IF (NC.GT.2) GO TO 2085
       WRITE (6,2001)
       GO TO 209
 2085  WRITE (6,2003)
  209  READ (5,206) CPS
       IF (CPS.NE.1.AND.CPS.NE.2.AND.CPS.NE.3) GO TO 420
C
C      THE PROGRAM NOW RECONSIDERS ITS PREVIOUSLY CHOSEN STRATEGY SINCE
C      SOUTH HAS NOW DECLARED HIS CPS.
C
       NC=NC+1
       CALL STRTGY(MOV,INCNT,PCNT,PCNTM,INCNTR,PCNTN,PCNTNM)
       NC=NC-1
C
C
  300  IF (NC.GT.2) GO TO 3001
       WRITE (6,301)
  301  FORMAT (//,' IT IS NOW TIME TO CARRY OUT THE STRATEGY OF EACH SIDE
     1.  THE COMPUTER''S MOVE IS LOCKED INTO THE SYSTEM.',/,' PLEASE IND
     2ICATE YOUR STRATEGY AS 1, 2, OR 3:')
       GO TO 3005
 3001  WRITE (6,3002)
 3002  FORMAT (//,' WHAT IS YOUR STRATEGY ?')
 3005  READ (5,206) STRATS
 3011  IF (STRATS.NE.1.AND.STRATS.NE.2.AND.STRATS.NE.3) GO TO 430
       WRITE (6,302) STRATN,STRATS
  302  FORMAT (/,' THE ACTUAL STRATEGIES CHOSEN BY EACH OPPONENT ARE AS F
     1OLLOWS:',/,5X,'NORTH(COMPUTER):',I3,/,5X,'SOUTH(PLAYER):',I5)
       IF (STRATN.EQ.1.AND.STRATS.EQ.1) GO TO 3021
       IF (STRATN.EQ.1.AND.STRATS.EQ.3) GO TO 3022
       IF (STRATN.EQ.3.AND.STRATS.EQ.3) GO TO 3023
       IF (STRATN.EQ.3.AND.STRATS.EQ.1) GO TO 3024
       GO TO 303
 3021  FACTXN=-1
       FACTXS=-1
```

```
      GO TO 303
 3022 FACTXN=4
      GO TO 303
 3023 FACTXN=2
      FACTXS=2
      GO TO 303
 3024 FACTXS=4
  303 CALL PATUPD
C
  317 PNOLD=PN
C       (THIS VALUE IS LATER USED TO DETERMINE ECONOMIC CONDITIONS.)
C
C     DETERMINE ISN
C
      IF (SN) 101,102,103
C
C     SN NEGATIVE
C
  101 IF (SN.LT.-4) GO TO 1011
      IF (SN.LE.-2) GO TO 1012
      ISN=4
      GO TO 104
 1012 ISN=3
      GO TO 104
 1011 IF (SN.LT.-6) GO TO 1013
      ISN=2
      GO TO 104
 1013 ISN=1
      GO TO 104
C
C     SN ZERO
C
  102 ISN=4
      GO TO 104
C
C     SN POSITIVE
C
  103 IF (SN.GT.4) GO TO 1031
      IF (SN.GE.2) GO TO 1032
      ISN=4
      GO TO 104
 1032 ISN=5
      GO TO 104
 1031 IF (SN.GT.6) GO TO 1033
      ISN=6
      GO TO 104
 1033 ISN=7
C
```

```
C       DETERMINE ISS
C
  104 IF (SS) 111,112,113
  111 IF (SS.LT.-4) GO TO 1111
      IF (SS.LT.-2) GO TO 1112
      ISS=4
      GO TO 105
 1112 ISS=3
      GO TO 105
 1111 IF (SS.LT.-6) GO TO 1113
      ISS=2
      GO TO 105
 1113 ISS=1
      GO TO 105
C
C       SS ZERO
C
  112 ISS=4
      GO TO 105
C
C       SS POSITIVE
C
  113 IF (SS.GT.4) GO TO 1131
      IF (SS.GE.2) GO TO 1132
      ISS=4
      GO TO 105
 1132 ISS=5
      GO TO 105
 1131 IF (SS.GT.6) GO TO 1133
      ISS=6
      GO TO 105
 1133 ISS=7
C
  105 WN=WN+VALUE(ISN,STRATN)+ECNXN
      WS=WS+VALUE(ISS,STRATS)+ECNXS
      JSTN=STRATN-2
      JSTS=STRATS-2
      IF (JSTN)106,107,108
  106 SN=SN+1
      GO TO 107
  108 SN=SN-1
  107 IF (JSTS) 109,120,110
  109 SS=SS+1
      GO TO 120
  110 SS=SS-1
  120 PN=PN+2*(VALUE(ISN,STRATN)+ECNXN)-5*(STRATN-2)+FACTXN
      PS=PS+2*(VALUE(ISS,STRATS)+ECNXS)-5*(STRATS-2)+FACTXS
      RW=WN-WS
```

```
      RS=SN-SS
C
C       (CALL ANALYSES PORTION OF STRTGY TO ANALYZE THE RESULTS OF THE
C         LAST MOVE TO DETERMINE IF STRTGY COULD HAVE DONE BETTER.)
      NC=NC+1
      CALL STRTGY(MOV,INCNT,PCNT,PCNTM,INCNTR,PCNTN,PCNTNM)
      NC=NC-1
C
      WHOCAL=0
      NFLAG=0
C       (RENEGOTIATE FLAGS CLEARED SINCE MOVE IS COMPLETE.)
C
      CALL ECONMY
C       (DETERMINE ECONOMIC CONDITIONS BY CALLING SUBROUTINE ECONMY.)
      DO 121 I=1,3
      DO 121 J=1,3
  121 COMPN(I,J)=RTABN(I,J)
      CALL TABCHG
      FACTXN=0
      FACTXS=0
      NC=NC+1
      CALL ECALC(ENACT,ESACT)
      NC=NC-1
      ENARRY(NC)=ENACT
      ESARRY(NC)=ESACT
      ENAVG=ENAVG+ENACT
      ESAVG=ESAVG+ESACT
C
C     IS IT END OF GAME YET?
C
C     THE NUMBER OF MOVES IN THE GAME VARIES RANDOMLY BETWEEN 10 AND 50.
C
      IF (NC.LT.10) GO TO 480
      IF (NC.GE.50) GO TO 499
      CALL RANDOM
      IF (YRAND.GE.0.9) GO TO 490
      IF (NC.GT.40.AND.YRAND.GE.0.4) GO TO 490
      IF (NC.GT.30.AND.YRAND.GE.0.5) GO TO 490
      IF (NC.GT.20.AND.YRAND.GE.0.6) GO TO 490
  480 NC=NC+1
      WRITE (6,4801) WN,SN,PN,WS,SS,PS
 4801 FORMAT (//,' THE RESULTS OF THE LAST MOVE ARE AS FOLLOWS:',//,
     121X,'WEALTH',5X,'STRENGTH',5X,'*POINTS*',/,
     2' COMPUTER (NORTH) *',I7,3X,'*',I8,4X,'*',I8,3X,'*',/,
     3' PLAYER (SOUTH)',3X,'*',I7,3X,'*',I8,4X,'*',I8,3X,'*',/)
      IF (IABS(RS).GE.10) GO TO 492
      IF (IABS(RW).GE.30) GO TO 493
      IF (TURN) 201,201,255
```

```
C
  492 IF (RS) 494,494,495
  493 IF(RW) 496,496,497
C
  410 WRITE (6,411)
  411 FORMAT (/,' *** YOUR SELECTION OF A CONCESSION POINT WAS NOT CORRE
     1CT.  THE CP MUST BE A SINGLE INTEGER 1, 2, OR 3.',/,' PLEASE INDIC
     2ATE YOUR CP AS 1(ARM), 2(STATUS QUO), OR 3(DISARM):')
      GO TO 2005
  420 WRITE (6,411)
      GO TO 209
  430 WRITE (6,431)
  431 FORMAT (/,' *** YOUR SELECTION OF A STRATEGY MUST BE A SINGLE INTE
     1GER 1, 2, OR 3.',/,' PLEASE INDICATE YOUR STRATEGY AS 1(ARM), 2(ST
     2ATUS QUO), OR 3(DISARM):')
      READ (5,206) STRATS
      GO TO 3011
C
  494 WRITE(6,4941)
 4941 FORMAT (//,' *** CONGRATULATIONS, YOU WON THIS GAME BASED ON YOUR
     1STRENGTH SUPERIORITY.')
      WON=-1
      NC=NC-1
      GO TO 491
  495 WRITE (6,4951)
 4951 FORMAT (//,' *** SORRY, YOU LOST THIS GAME BASED ON YOUR STRENGTH
     1DEFICIENCY.')
      WON=1
      NC=NC-1
      GO TO 491
  496 WRITE (6,4961)
 4961 FORMAT (//,' *** CONGRATULATIONS, YOU WON THIS GAME BASED ON YOUR
     1WEALTH SUPERIORITY.')
      WON=-1
      NC=NC-1
      GO TO 491
  497 WRITE (6,4971)
 4971 FORMAT (//,'*** SORRY, YOU LOST THIS GAME BASED ON YOUR WEALTH DEF
     1ICIENCY.')
      WON=1
      NC=NC-1
      GO TO 491
  499 WRITE (6,4991)
 4991 FORMAT (//,' *** THE GAME HAS NOW ENDED.  THE PARTICIPANT WITH THE
     1 MOST POINTS (POINTS = (2*WEALTH)+(5*STRENGTH) IS DECLARED THE WIN
     2NER.')
      IF (PN-PS) 391,392,393
  391 WON=-1
```

```
      GO TO 491
  392 WON=0
      GO TO 491
  393 WON=1
      GO TO 491
  490 WRITE (6,4901) NC
 4901 FORMAT (//,' *** BY A RANDOM SELECTION, THE UMPIRE HAS DECIDED TO
     1END THIS GAME AFTER',I3,' MOVES.',/,' THE PARTICIPANT WITH THE MOS
     2T POINTS (POINTS = (2*WEALTH)+(5*STRENGTH)) IS DECLARED THE WINNER
     3.')
      IF (PN-PS) 3911,3922,3933
 3911 WON=-1
      GO TO 491
 3922 WON=0
      GO TO 491
 3933 WON=1
  491 WRITE (6,4911) WN,SN,PN,WS,SS,PS
 4911 FORMAT (//,' THE FINAL GRAND TOTALS FOR THIS GAME ARE:',//,
     121X,'WEALTH',5X,'STRENGTH',5X,'*POINTS*',/,18X,'*',10X,'*',12X,
     2'*',11X,'*',/,' COMPUTER (NORTH) *',I7,3X,'*',I8,4X,'*',I8,3X,'*',
     3/,18X,'*',10X,'*',12X,'*',11X,'*',/,' PLAYER (SOUTH)',3X,'*',I7,
     43X,'*',I8,4X,'*',I8,3X,'*',/,18X,'*',10X,'*',12X,'*',11X,'*',//)
      IF (WON) 394,395,396
  394 WRITE (6,3941) PLAYER
 3941 FORMAT (/,5X,A4,' IS THE WINNER.  THANK YOU FOR PLAYING.')
      GO TO 1000
  395 WRITE (6,3951)
 3951 FORMAT (/,' THE GAME ENDED IN A TIE.  THANK YOU FOR PLAYING.')
      GO TO 1000
  396 WRITE (6,3961)
 3961 FORMAT (/,' THE COMPUTER WON THE GAME.  THANK YOU FOR PLAYING.')
C
C        (UPDATE HISTORY:)
 1000 APN=APN+PN
      APS=APS+PS
      IF (WON) 161,161,160
C
C        (IF THE COMPUTER WON THE GAME, INSERT THE STRATEGY PARAMETERS
C           INTO THE HISTORY OF THE PLAYER:)
  160 CHAR=RLINK3(CATLG)
      PARAM=LLINK4(CHAR)
      NAME4(PARAM)=P(1)
      RLINK4(PARAM)=P(2)
      LLINK4(PARAM)=P(3)
      DOWN4(PARAM)=P(4)
      GO TO 162
  161 CHAR=RLINK3(CATLG)
      PARAM=LLINK4(CHAR)
```

```
      NAME4(PARAM)=10
      RLINK4(PARAM)=10
      LLINK4(PARAM)=10
      DOWN4(PARAM)=20
  162 WRITE (6,1605) (P(I),I=1,4)
 1605 FORMAT (/,' PARAMETERS AT END OF GAME ARE:',4I5)
C
      CHAR=RLINK3(CATLG)
      TOTAL1=NAME4(LLINK4(PATRNS))
      TOTAL2=RLINK4(LLINK4(PATRNS))
      TOTAL3=LLINK4(LLINK4(PATRNS))
      IF (TOTAL1.GT.TOTAL2.AND.TOTAL1.GT.TOTAL3) GO TO 150
      IF (TOTAL3.GT.TOTAL1.AND.TOTAL3.GT.TOTAL2) GO TO 151
      NAME2(RLINK4(CHAR))=2
      GO TO 152
  150 NAME2(RLINK4(CHAR))=1
      GO TO 152
  151 NAME2(RLINK4(CHAR))=3
  152 ENAVG=ENAVG/NC
      ESAVG=ESAVG/NC
      NAME2(NAME4(CHAR))=ENAVG
      DOWN2(NAME4(CHAR))=ESAVG
      J=0
      K=0
      DO 157 I=1,NC
      IF (ENARRY(I).EQ.10.OR.ENARRY(I).EQ.20) J=J+1
      IF (ENARRY(I).EQ.30.OR.ENARRY(I).EQ.40) K=K+1
  157 CONTINUE
      IF (J.GT.K) HCLAS=2
      IF (J.LT.K) HCLAS=3
      IF (J.EQ.K) HCLAS=1
      DOWN2(RLINK4(CHAR))=HCLAS
      CALL TYPELB(INCNTR,WON,INCNT)
      CALL SEQLB(INCNTR,WON)
      CALL DPATNS
      GO TO 6001
 6000 WRITE (6,702)
  702 FORMAT('  DO YOU WANT TO PRINT OUT THE PERMANENT MEMORY. YES OR NO
     1. USE A3 FORMAT RIGHT JUSTIFIED'/)
      READ(5,703) DU
  703 FORMAT(A3)
      CALL SAVE(INCNT,INCNTR,DU)
C
C
      STOP
      END
```

```
      SUBROUTINE TABCHG
C
C     THIS SUBROUTINE UPDATE THE TABLES AS A RESULT OF THE LAST MOVE.
C     IT ALSO DETERMINES IF AN "ECONOMIC CONDITIONS" CHANGE IS DUE.
C     ECONOMIC CHANGES ARE RANDOMLY GENERATED AT RANDOM TIMES.
C
      IMPLICIT INTEGER (A-W)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
C
      TI=1
      TJ=1
    1 TTN=2*VALUE(ISN,TI)-5*(TI-2)
    2 TTS=2*VALUE(ISS,TJ)-5*(TJ-2)
      RTABN(TI,TJ)=TTN-TTS
      RTABS(TI,TJ)=TTS-TTN
      IF(TJ.EQ.3) GO TO 3
      TJ=TJ+1
      GO TO 2
    3 ATABN(TI)=TTN
      ATABS(TI)=2*VALUE(ISS,TI)-5*(TI-2)
      IF(TI.EQ.3) GO TO 10
      TI=TI+1
      TJ=1
      GO TO 1
   10 RTABN(1,1)=RTABN(1,1)-1
      RTABS(1,1)=RTABS(1,1)-1
      RTABN(1,3)=RTABN(1,3)+4
      RTABS(3,1)=RTABS(3,1)+4
      RTABN(3,3)=RTABN(3,3)+2
      RTABS(3,3)=RTABS(3,3)+2
      ATABN(1)=ATABN(1)+2
      ATABS(1)=ATABS(1)+2
      ATABN(3)=ATABN(3)+1
      ATABS(3)=ATABS(3)+1
C       (THE ATABN(S) FACTORS APPROXIMATE THE GAINS FOR COOPERATING
C         IN DISARMING, OR FOR ONE SIDE ARMING WHILE OTHER DISARMS.)
C
C     THIS COMPLETES THE TABLE CHANGES.  THE ECONOMIC CONDITION IS NOW
C     DETERMINED.  THE FIRST STEP IS TO DETERMINE IF A CHANGE IS DUE.
C     IF IT IS, THE CONDITIONS FOR THE OPPONENTS (COMPUTER IS "NORTH",
C     OPPONENT IS "SOUTH")ARE PLACED INTO PARAMETERS ECNXN AND ECNXS
C     RESPECTIVELY.
C
      CALL RANDOM
      IF (YRAND.GE.0.6) GO TO 30
C      (STMT 30 IS "RETURN", BRANCH THERE IF NO CHANGE IS DUE)
```

```
C
C     IN ORDER TO DETERMINE THE ECONOMIC CONDITIONS, A RANDOM NUMBER
C     NUST FIRST BE GENERATED.
C
      CALL RANDOM
C     THE ECONOMIC CONDITION FOR THE COMPUTER (NORTH) IS CALCULATED
C     FIRST AND PLACED INTO ECNXN.
C
C     YRAND IS THE RANDOM NUMBER USED TO DETERMINE THE ECONOMIC CHANGE.
      IF (YRAND.GE.0.7) GO TO 35
      IF (YRAND.LE.0.3) GO TO 33
      ECNXN=0
      GO TO 40
   33 IF (YRAND.LE.0.1) GO TO 34
      ECNXN=-1
      GO TO 40
   34 ECNXN=-2
      GO TO 40
   35 IF (YRAND.GE.0.9) GO TO 36
      ECNXN=1
      GO TO 40
  36  ECNXN=2
C
C     THE ECONOMIC CONDITION FOR SOUTH IS THEN CALCULATED AND PLACED
C     INTO ECNXS.  IT USES A DIFFERENT RANDOM NO. THAN FOR NORTH.
C
  40  CALL RANDOM
      IF (YRAND.GE.0.7) GO TO 45
      IF(YRAND.LE.0.3) GO TO 43
      ECNXS=0
      RETURN
   43 IF (YRAND.LE.0.1) GO TO 44
      ECNXS=-1
      RETURN
   44 ECNXS=-2
      RETURN
   45 IF(YRAND.GE.0.9) GO TO 46
      ECNXS=1
      RETURN
  46  ECNXS=2
  30  RETURN
      END
```

```
      SUBROUTINE RANDOM
C
C     THE PURPOSE OF THIS SUBROUTINE IS TO GENERATE A FLOATING POINT
C     RANDOM NUMBER IN THE RANGE 0-1.0.  THE PROCEDURE IS ESSENTIALLY
C     IDENTICAL TO THE "SCIENTIFIC SUBROUTINE PACKAGE" PROCEDURE "RANDU".
C
C     PASSING PARAMETER INRAND IS USED TO START THE PROCESS OF RANDOM
C     NUMBER GENERATION.  IT IS ANY ODD INTEGER NUMBER WITH NINE OR LESS
C     DIGITS INPUT IN A (HOPEFULLY) RANDOM MANNER WHEN THE PLAYER
C     INITIALLY SIGNS INTO THE SYSTEM.  AFTER THE FIRST ENTRY TO THIS
C     SUBROUTINE IN ANY ONE GAME, INRAND BECOMES THE PREVIOUS VALUE OF
C     INRAND COMPUTED BY THIS SUBROUTINE.
C
      IMPLICIT INTEGER (A-W)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      INRAND=INRAND*65539
      IF (INRAND) 31,32,32
   31 INRAND=INRAND+2147483647+1
   32 YRAND=INRAND
      YRAND=YRAND*.4656613E-9
      RETURN
      END


      SUBROUTINE INITL
C
C          THIS SUBROUTINE INITIALIZES AVAILABLE CELLS FOR 250,333,
C          AND 500 NODES
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      N=999
      M=999
      P=999
      DO 10 I=4,N,4
   10 NAME4(I)=I+1
      AVAIL4=1
      NAME4(1000)=0
      DO 11 I=2,M,2
   11 NAME2(I)=I+1
      NAME2(1000)=0
```

```
      AVAIL2=1
      DO 12 I=3,P,3
   12 NAME3(I)=I+1
      AVAIL3=1
      NAME3(999)=0
      RETURN
      END


      SUBROUTINE GET2(K)
C
C             THIS SUBROUTINE GETS A CELL FROM THE LIST OF AVAILABLE
C             CELLS IN AVAIL2. "K" IS THE PASSING PARAMETER FOR SUBSCRIP
C             OF CELL OBTAINED. "AVAIL2" IS THE POINTER TO THE NEXT
C             CELL IN THE LIST OF AVAIL2 CELLS.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      IF(AVAIL2.EQ.0) GOTO 2
      K=AVAIL2
      AVAIL2=DOWN2(AVAIL2)
      RETURN
    2 WRITE(6,3)
    3 FORMAT(1H0,5X,'UNDERFLOW EXISTS IN AVAIL2 LIST OF AVAILABLE CELL
     1S.')
      RETURN
      END


      SUBROUTINE GET3(L)
C
C              THIS SUBROUTINE GETS A CELL FROM THE LIST OF AVAILABLE
C              CELLS IN AVAIL3. "L" IS THE PASSING PARAMETER FOR SUBSCRI
C              OF CELL OBTAINED. "AVAIL3" IS THE POINTER TO THE NEXT
C              CELL IN THE LIST OF AVAIL3 CELLS.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
```

```
      IF(AVAIL3.EQ.0) GOTO 2
      L=AVAIL3
      AVAIL3=DOWN3(AVAIL3)
      RETURN
    2 WRITE(6,3)
    3 FORMAT(1H0,5X,'UNDERFLOW EXISTS IN AVAIL3 LIST OF AVAILABLE CELL
     1S.')
      RETURN
      END


      SUBROUTINE GET4(J)
C
C           THIS SUBROUTINE GETS A CELL FROM THE AVAILABLE CELLS IN
C           AVAIL4. "J" IS THE PASSING PARAMETER FOR SUBSCRIPT OF
C           CELL OBTAINED. "AVAIL4" IS THE POINTER TO NEXT CELL IN
C           THE LIST OF AVAIL4 CELLS.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      IF(AVAIL4.EQ.0) GOTO 2
      J=AVAIL4
      AVAIL4=DOWN4(AVAIL4)
      RETURN
    2 WRITE(6,3)
    3 FORMAT (1H0,5X,'UNDERFLOW EXISTS IN AVAIL4 LIST OF AVAILABLE CEL
     1LS.')
      RETURN
      END


      SUBROUTINE COUNT(K1,J1,L1)
C
C            THIS SUBROUTINE COUNT THE NUMBER OF CELLS STILL AVAILABLE
C            "K1,J1,L1" ARE PASSING PARAMETERS THE PROVIDE THE COUNT
C            FOR EACH LIST.   K1==>AVAIL4,J1==>AVAIL2,L1==>AVAIL3.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
```

```
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      K1=0
      J1=0
      L1=0
      A4=AVAIL4
      A3=AVAIL3
      A2=AVAIL2
    1 IF(A2.EQ.0)GOTO 2
      A2=DOWN2(A2)
      J1=J1+1
      GOTO 1
    2 IF(A4.EQ.0)GOTO 3
      A4=DOWN4(A4)
      K1=K1+1
      GOTO 2
    3 IF(A3.EQ.0)GOTO 4
      A3=DOWN3(A3)
      L1=L1+1
      GOTO 3
    4 RETURN
      END

      SUBROUTINE STRTGY(MOV,INCNT,PCNT,PCNTM,INCNTR,PCNTN,PCNTNM)
C
C        **********************************************************
C        *                                                        *
C        *  THE NINE SUBROUTINES WITHIN THIS SECTION SUPPORT THE  *
C        *       REASONING CAPABILITIES OF THE PROGRAM.           *
C        *                                                        *
C        **********************************************************
C
C
C     THIS IS ONE OF THE KEY SUBROUTINES OF THE SYSTEM IN THAT IT IS
C     THE SUBROUTINE IN WHICH THE "THOUGHT PROCESSES" OCCUR. THIS
C     SUBROUTINE HAS THE FOLLOWING FUNCTIONS:
C         (1) ANALYZE ALL FACTORS AVAILABLE AND DECIDE UPON A STRATEGY
C     FOR THE MOVE. THIS IS DONE BY USING A VOTING PROCESS ON A
C     POLYNOMIAL.
C         (2) RECONSIDER THE STRATEGY CHOSEN IF THE COMPUTER WAS FIRST
C     TO DECLARE HIS CONCESSION POINT. THE RECONSIDERATION IS DONE IN
C     LIGHT OF THE PROPOSED STRATEGY OF SOUTH, THE COMPUTER'S OPPONENT.
C         (3) ANALYSIS OF THE COMPLETED MOVE TO DETERMINE IF THE
C     PARAMETERS USED FOR THE POLYNOMIAL COEFFICIENTS NEED BE TUNED UP
C     OR DOWN TO GIVE A BETTER SOLUTION.
C
      IMPLICIT INTEGER (A-W)
      COMMON/TDP4/SEQ(20),SCONTR
```

```
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/PAR/P(4),S(4),PRBLS(5)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,FFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/EEE/EN,ES,TOPEN,TOPES
      COMMON/ENP/ENARRY(50),ESARRY(50)
      COMMON/ST/STRUE,LASTGO,NFLAG,TURN,ANAL,RECON
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFEN,PMOVEN,PMOVES
      COMMON/TDPS/TYPENU,TYPE1,TYSOU,TYNOR
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DIMENSION CF(4)
C
C
C          (IF THE SYSTEM REMEMBERS HAVING PLAYED THIS OPPONENT, THE
C             PARAMETERS USED FOR THE COEFFICIENTS FOR THE TERM OF THE
C             POLYNOMIAL ARE TAKEN FROM THE HISTORY OF THIS PLAYER IN
C             LONG TERM MEMORY.  IF NOT, THE PARAMETERS FOUND BELOW ARE
C             USED.  --  THE FIRST TIME THIS SUBROUTINE IS CALLED IN A
C             GAME, THE PARAMETERS DESCRIBED ABOVE ARE USED.  AFTER THE
C             FIRST MOVE, THESE PARAMETERS MAY BE MODIFIED BY THE ANALYSIS
C             PORTION OF THIS SUBROUTINE.)
C
      IF (NC.GT.1) GO TO 7
      CHAR=RLINK3(CATLG)
      IF (NAME4(LLINK4(CHAR)).EQ.0) GO TO 6000
      P(1)=NAME4(LLINK4(CHAR))
      P(2)=RLINK4(LLINK4(CHAR))
      P(3)=LLINK4(LLINK4(CHAR))
      P(4)=DOWN4(LLINK4(CHAR))
      WRITE (6,61) (P(I),I=1,4)
   61 FORMAT (//,' PARAMETERS AT START OF GAME ARE:',4I5)
      GO TO 7
 6000 P(1)=10
      P(2)=10
      P(3)=10
      P(4)=20
      WRITE (6,61) (P(I),I=1,4)
C
C
C
C         (THE FIRST STEP IS TO DETERMINE IF SOUTH'S CONCESSION POINT WAS
C             DECLARED FIRST. IF SO, THIS CPS IS USED IN DETERMINING THE
```

```
C           FIRST TERM OF THE POLYNOMIAL. IF NOT, THE FIRST TERM IS NOT
C           USED UNTIL THE TIME OF RECONSIDERATION OF THE STRATEGY AFTER
C           SOUTH HAS DECLARED HIS CPS.)
C
    7   IF (TURN) 8,8,90
C         (TURN IS POSITIVE IF SOUTH HAS ALREADY DECLARED A CPS.)
    8   IF (RECON) 9,9,90
C         (RECONSIDERATION FLAG IS POSITIVE IF THIS IS A RECONSIDERATION
C           OF THE STRATEGY.)
    9   RECON=10
C         (SET THE RECON FLAG POSITIVE IN ANTICIPATION OF FUTURE RECON.)
        CF(1)=0
        GO TO 20
C
   90   IF (ANAL) 5,1,70
C         (THE ANAL FLAG IS USED TO DETERMINE IF THE ANALYSIS PORTION OF
C           THE ROUTINE IS TO BE USED, BYPASSING THE STRATEGY PORTION.)
C
C              (THIS STEP OF THE STRATEGY PORTION OF THE SUBROUTINE IS TO
C           DETERMINE IF THE COMPUTER IS IN DANGER OF LOSING BECAUSE OF
C           RELATIVE STRENGTH OR RELATIVE WEALTH DEFICIENCIES. IF SO,
C           IMMEDIATE ACTION MUST BE TAKEN TO INCREASE STRENGTH OR WEALTH
C           ACCORDINGLY.)
    1   IF (RS.GT.-7) GO TO 2
        IF (TURN.GT.0.AND.CPS.EQ.1.AND.SS.GE.4) GO TO 101
        STRATN=1
        GO TO 4
  101   WRITE (6,1010)
 1010   FORMAT (/,' IT IS REQUESTED THAT WE RENEGOTIATE.',/,
     1'    YOU ARE QUITE STRONG, YET YOU PROPOSE ARMING EVEN FURTHER.',/,
     2' AFTER RENEGOTIATING, WHAT IS YOUR NEW CP ?')
        READ (5,1011) CPS
 1011   FORMAT (I1)
        STRATN=1
        GO TO 4
    2   IF (RW.GT.-23) GO TO 10
        IF (ISN.EQ.1) GO TO 3
        STRATN=3
        GO TO 4
    3   STRATN=2
    4   ANAL=-10
        RETURN
    5   ANAL=0
        RECON=-10
        RETURN
C
C
C         (IF SOUTH HAS DECLARED A CPS, THIS MUST BE ANALYZED AND A
```

```
C           COEFFICIENT "CF1" ASSIGNED TO THE 1ST TERM OF THE POLYNOMIAL.)
C
   10 ANAL=10
C        (THIS SETS THE ANAL FLAG SO THAT ANALYSIS WILL
C           BE PERFORMED WHEN REQUESTED.)
C
      GO TO (11,12,12),CPS
C
C        (A BRANCH TO 11 INDICATES CPS WAS TO ARM.)
   11 IF (SS.LE.4) GO TO 12
C        (NO BRANCH INDICATES THAT THE COMPUTER'S OPPONENT IS QUITE
C           STRONG ALREADY, YET HE IS ARMING EVEN FURTHER: CONSIDER
C           RENEGOTIATION. BRANCHING TO 12 INDICATES NO RENEGOTIATE.)
C
      IF (NFLAG.EQ.1) GO TO 12
C        (NFLAG=1 INDICATES THAT WE HAVE RENEGOTIATED, BUT SOUTH
C           PERSISTS IN ARMING.)
      NFLAG=1
      IF (RS.LT.-2) GO TO 1111
C        (NO BRANCH INDICATES THAT BOTH SIDES HAVE BEEN ARMING GREATLY.)
      PROBLM=1
C        (I.E., "LET'S QUIT THE ARMS RACE.")
      CALL RENEG(PROBLM,WHOCAL)
      GO TO 10
 1111 Z=NAME4(LLINK4(PATRNS))/NC
      IF (Z.LE.0.5) GO TO 1112
      PROBLM=2
C        (I.E., SOUTH IS QUITE STRONG, HAS MUCH STRENGTH SUPERIORITY,
C           AND HAS ARMED OVER 50% OF THE TIME.)
      CALL RENEG(PROBLM,WHOCAL)
      GO TO 10
 1112 J=0
      MOVES=DOWN4(PATRNS)
 1113 IF (NAME2(MOVES).EQ.1) J=J+1
      IF (DOWN2(MOVES).EQ.0) GO TO 1114
      MOVES=DOWN2(MOVES)
      GO TO 1113
 1114 MOVES=DOWN4(PATRNS)
      IF (J.LT.2) GO TO 12
      J=0
      PROBLM=3
C        (I.E., SOUTH IS QUITE STRONG AND HAS MUCH STRENGTH SUPERIORITY,
C           YET HAS ARMED AT LEAST 2 OUT OF THE LAST 3 MOVES.)
      CALL RENEG(PROBLM,WHOCAL)
      GO TO 10
C
C        (END CHECK FOR RENEGOTIATE BLOCK.)
C
```

```
C
C        (A BRANCH TO 12 INDICATES THAT CPS WAS TO MAINTAIN THE STATUS
C          QUO OR TO DISARM. PROCEEDING HERE THROUGH THE LAST SECTION
C          INDICATES THAT CPS WAS TO ARM, BUT THE DECISION WAS MADE NOT
C          TO RENEGOTIATE.)
C
   12 CALL ENPAT(PTRUTH)
C        (PTRUTH=0 IMPLIES SOUTH IS PROBABLY NOT TELLING THE TRUTH,
C          PTRUTH=1 IMPLIES HE PROBABLY IS.)
      IF (PTRUTH.EQ.0) GO TO 121
      PRBLS(1)=CPS
      J=CPS
      GO TO 13
C
C        (IF EN PATTERN INDICATES THAT SOUTH WILL PROBABLY NOT TELL THE
C          TRUTH, CHECK HONESTY CLASS TO DETERMINE IN WHICH DIRECTION
C          HE WILL GO.)
  121 I=DOWN2(RLINK4(CHAR))
      GO TO (122,123,124),I
  122 PRBLS(1)=1
      J=1
      GO TO 13
  123 PRBLS(1)=CPS
      J=CPS
      GO TO 13
  124 PRBLS(1)=3
      J=3
C
C        (NEXT CHECK WEIGHTED EN)
   13 TOPEN=EN
      IF (NAME3(TOPEN).LT.35) GO TO 131
C        (NO BRANCH INDICATES GOOD RELIABILITY)
      PRBLS(2)=CPS
      GO TO 14
C        (IF BRANCH TO 131, CHECK TO SEE IF EN IS INCREASING. IF SO,
C          ASSUME HE IS TELLING TRUTH TO IMPROVE HIS RELIABILITY IMAGE.)
  131 I=NAME3(DOWN3(TOPEN))
      IF (NAME3(TOPEN).GT.I) GO TO 132
      PRBLS(2)=J
      GO TO 14
  132 PRBLS(2)=CPS
C
C        (NEXT CHECK AGGRESSIVENESS CLASS, I.E. HOW AGGRESSIVE HE IS.T
   14 PRBLS(3)=NAME2(RLINK4(CHAR))
C
C        (NOW CHECK HIS BEST MOVES.)
      HISMAX=MAXO(ATABS(1),ATABS(2),ATABS(3))
      DO 15 I=1,3
```

```
      IF (HISMAX.EQ.ATABS(I)) GO TO 152
   15 CONTINUE
      WRITE (6,151)
  151 FORMAT (//,' *** S/R STRTGY ERROR #1 ***')
      RETURN
  152 PRBLS(4)=I
      HISMAX=MAX0(RTABS(1,1),RTABS(1,2),RTABS(1,3),RTABS(2,1),
     1RTABS(2,2),RTABS(2,3),RTABS(3,1),RTABS(3,2),RTABS(3,3))
      DO 153 I=1,3
      DO 153 J=1,3
      IF (RTABS(I,J).EQ.HISMAX) GO TO 155
  153 CONTINUE
      WRITE (6,154)
  154 FORMAT (//, ' *** S/R STRTGY ERROR #2 ***')
      RETURN
  155 PRBLS(5)=J
C
C       (NOW DETERMINE HIS PROBABLE STRATEGY BASED ON CPS.)
      S(1)=0
      S(2)=0
      S(3)=0
      DO 16 I=1,5
      IF (PRBLS(I).EQ.1)  S(1)=S(1)+1
      IF (PRBLS(I).EQ.2)  S(2)=S(2)+1
      IF (PRBLS(I).EQ.3)  S(3)=S(3)+1
   16 CONTINUE
      HISMAX=MAX0(S(1),S(2),S(3))
      DO 161 I=1,3
      IF (HISMAX.EQ.S(I)) GO TO 1611
  161 CONTINUE
      WRITE (6,163)
      RETURN
 1611 S(1)=0
      S(2)=0
      S(3)=0
      HISMAX=I
C
C       (PICK COMPUTER'S VOTE FOR STRATEGY SELECTION BASED ON CPS TO
C          MAXIMIZE RELATIVE GAIN)
      S(1)=MAX0(RTABN(1,HISMAX),RTABN(2,HISMAX),RTABN(3,HISMAX))
      DO 162 I=1,3
      IF (S(1).EQ.RTABN(I,HISMAX)) GO TO 164
  162 CONTINUE
      WRITE (6,163)
  163 FORMAT (//,' *** S/R STRTGY ERROR #3 ***')
      RETURN
  164 S(1)=I
      CF(1)=P(1)
```

```
      IF (HISMAX.EQ.3.AND.S(1).EQ.1) CF(1)=P(1)+2
C
   17 IF (RECON) 20,20,50
C        (THIS COMPLETES THE RECONSIDERATION PHASE)
C
C
C     THE SECOND TERM OF THE POLYNOMIAL IS BASED ON "GOAL". THIS IS
C     BASED ON ANALYSIS OF THE STRENGTH, WEALTH, AND POINTS SO FAR, AND
C     SELECTION OF THE GOAL OF THIS MOVE: OPTIMUM STRATEGY, MAXIMUM
C     GAIN, OR MINIMUM LOSS.  A COEFFICIENT CF2 IS THEN ASSIGNED TO THIS
C     TERM OF THE POLYNOMIAL.
C
   20 RP=PN-PS
      IF (RP) 22,23,24
C
C        (IF COMPUTER'S POINTS LESS THAN PLAYER'S:)
   22 IF (SN.LT.-4) GO TO 221
  242 CALL MAXSTR(MAXGN)
      S(2)=MAXGN
      GO TO 29
  221 S(2)=1
      GO TO 29
C
C        (IF COMPUTER'S POINTS = PLAYER'S POINTS:)
   23 IF (SN.LT.-4) GO TO 221
      CALL OPTSTR(STRATO)
      S(2)=STRATO
      GO TO 29
C
C        (IF COMPUTER'S POINTS GREATER THAN PLAYER'S:)
   24 IF (SN) 241,242,243
  241 IF (RS) 221,242,243
  243 CALL MINSTR(MINLOS)
      S(2)=MINLOS
C
C        (DETERMINE CF2.)
   29 CF(2)=P(2)
C
C     THE THIRD TERM OF THE STRATEGY POLYNOMIAL IS BASED ON
C     "LOOK-AHEAD" AND "GUESS-OPPOSITE".
C         LOOK-AHEAD IS DETERMINED BY PATTERN MATCHING THE STRATEGIES
C     EMPLOYED BY THE COMPUTER'S OPPONENT AGAINST THE STRATEGY LIBRARY
C     IN LONG-TERM MEMORY, THEN FOLLOWING THE BEST DEFENSE AS ALREADY
C     DETERMINED THEREIN.
C         A "GUESS-OPPOSITE" AGAINST THIS STRATEGY IS INFREQUENTLY
C     EMPLOYED WHERE IT CAN PROVIDE A GOOD RELATIVE GAIN AND SERVE TO
C     CONFUSE SOUTH. IT IS NOT USED VERY OFTEN, BECAUSE THE SYSTEM
C     STRIVES TO MAINTAIN A GOOD IMAGE OF RELIABILITY.
```

```
C
      IF (NC.GT.2) GO TO 31
      IF (NAME4(HIST)) 302,30,302
C        (NAME4(HIST)=0 IF WE HAVE NOT PLAYED THIS OPPONENT BEFORE AND
C           THUS HAVE NO PRIOR KNOWLEDGE OF HIS PROBABLE STRATEGY.)
   30 IF (LLINK4(HIST)) 305,301,305
  305 NORSO=0
      CALL CLSTYP(NORSO)
      IF (PMOVES.EQ.0) GO TO 301
      S(3)=MAXO(RTABN(1,PMOVES),RTABN(2,PMOVES),RTABN(3,PMOVES))
      DO 3051 I=1,3
      IF (S(3).EQ.RTABN(I,PMOVES)) GO TO 3055
 3051 CONTINUE
      WRITE (6,3052)
 3052 FORMAT (' *** S/R STRTGY ERROR #3A ***')
      CF(3)=C
      GO TO 40
 3055 S(3)=I
      CF(3)=P(3)
      GO TO 40
  301 CALL RANDOM
      IF (YRAND.GT.0.33) GO TO 3011
      S(3)=1
      GO TO 3059
 3011 IF (YRAND.GT.0.67) GO TO 3012
      S(3)=2
      GO TO 3059
 3012 S(3)=3
 3059 CF(3)=P(3)*2
      GO TO 40
C
C        (IF THIS OPPONENT HAS PLAYED BEFORE, ASSUME HE WILL FOLLOW THE
C           SAME INITIAL STRATEGY. THE COMPUTER THEN PICKS THE BEST
C           DEFENSE AGAINST THIS INITIAL STRATEGY.)
  302 MOVE1=NAME4(NAME4(HIST))
      MOVE2=RLINK4(NAME4(HIST))
      GO TO (303,304),NC
  303 S(3)=MAXO(RTABN(1,MOVE1),RTABN(2,MOVE1),RTABN(3,MOVE1))
      DO 3031 I=1,3
      IF (S(3).EQ.RTABN(I,MOVE1)) GO TO 3033
 3031 CONTINUE
      WRITE (6,3032)
 3032 FORMAT (//,' *** S/R STRTGY ERROR #4 ***')
      RETURN
 3033 S(3)=I
      CF(3)=P(3)
      GO TO 40
  304 S(3)=MAXO(RTABN(1,MOVE2),RTABN(2,MOVE2),RTABN(3,MOVE2))
```

```
      DO 3041 I=1,3
      IF (S(3).EQ.RTABN(I,MOVE2)) GO TO 3043
 3041 CONTINUE
      WRITE (6,3042)
 3042 FORMAT (//,' *** S/R STRTGY ERROR #5 ***')
      RETURN
 3043 S(3)=I
      CF(3)=P(3)
      GO TO 40
   31 IF(NC.GT.4)GOTO 32
      CALL CLSMVS(MOV,INCNT,PCNT,PCNTM,INCNTR)
      IF (DEFES.GT.0) GO TO 311
      IF (BDEFS.GT.0) GO TO 311
      CF(3)=0
      GO TO 40
C
  311 S(3)=MAXO(RTABN(1,PMOVES),RTABN(2,PMOVES),RTABN(3,PMOVES))
      DO 3111 I=1,3
      IF (S(3).EQ.RTABN(I,PMOVES)) GO TO 312
 3111 CONTINUE
      WRITE (6,3143)
 3143 FORMAT (//,' *** S/R STRTGY ERROR #6 ***')
      CF(3)=0
      GO TO 40
C
  312 CALL CLSMVN(MOV,INCNT,PCNTN,PCNTNM,INCNTR)
      IF (OFFEN.GT.0) GO TO 313
      IF (BOFFN.GT.0) GO TO 313
      S(3)=I
      CF(3)=P(3)/2
      GO TO 39
C
C       (HAVE BOTH PMOVES AND PMOVEN:)
  313 IF (I.EQ.PMOVEN) GO TO 314
      S(3)=I
      CF(3)=P(3)/2
      GO TO 39
  314 S(3)=PMOVEN
      CF(3)=P(3)
      GO TO 39
C
   32 NORSO=C
      CALL CLSTYP(NORSO)
      IF (PMOVES.GT.0) GO TO 321
      CF(3)=C
      GO TO 40
  321 S(3)=MAXO(RTABN(1,PMOVES),RTABN(2,PMOVES),RTABN(3,PMOVES))
      DO 3211 I=1,3
```

```
      IF (S(3).EQ.RTABN(I,PMOVES)) GO TO 322
 3211 CONTINUE
      WRITE (6,3243)
 3243 FORMAT (//,' *** S/R STRTGY ERROR #7 ***')
      CF(3)=C
      GO TO 40
C
  322 NORSO=1
      CALL CLSTYP(NORSO)
      IF (PMOVEN.GT.0) GO TO 323
      S(3)=I
      CF(3)=P(3)/2
      GO TO 39
C
C        (HAVE BOTH PMOVES AND PMOVEN:)
  323 IF (I.EQ.PMOVEN) GO TO 324
      S(3)=I
      CF(3)=P(3)/2
      GO TO 38
  324 S(3)=PMOVEN
      CF(3)=P(3)
      GO TO 39
C
C
C
C        (NOW DETERMINE IF WE SHOULD GUESS OPPOSITE.)
   38 I=NC-LASTGO
      IF (I.LT.5) GO TO 39
C        (DON'T GUESS OPPOSITE MORE THAN EVERY FIVE MOVES.)
C        (ALSO DON'T GUESS OPPOSITE IF COMPUTER'S RELIABILITY IS LOW:)
      TOPES=ES
      IF (NAME3(TOPES).LT.40) GO TO 39
C        (GUESS OPPOSITE, IF USED, IS AGAINST OUR PATTERN OF MOVES:)
      IF (PMOVEN.EQ.0) GO TO 39
      STRUE=PMOVEN
      LASTGO=NC
      CF(3)=P(3)*2
      GO TO 40
C
C        (IF GUESS OPPOSITE NOT CHOSEN:)
   39 CALL RANDOM
      IF (YRAND.GT.0.2) GO TO 40
      IF (YRAND.GT.0.1) GO TO 395
      IF (S(3).EQ.1) S(3)=3
      IF (S(3).EQ.3) S(3)=1
      CF(3)=P(3)*3
      LASTGO=NC
      GO TO 40
```

```
  395 S(3)=2
      CF(3)=P(3)*3
      LASTGO=NC
C
C
C     THE FOURTH TERM OF THE POLYNOMIAL IS BASED ON THE EXPECTED
C     ECONOMIC CONDITIONS.  COEFFICIENT CF4 IS ASSIGNED TO THIS TERM.
C
   40 IF (EFLAG) 41,42,43
C
C        (EFLAG NEGATIVE INDICATES THAT A "BOOM" IS PROBABLY IN PROGRESS
C          AND THAT PRICES ARE HIGH, AND THIS IS A BAD TIME TO ARM.)
   41 S(4)=3
      CF(4)=P(4)
      GO TO 50
C
C        (EFLAG ZERO INDICATES THAT THE PROBABLE STATE OF THE ECONOMY
C          IS "NORMAL". THUS NO SPECIAL CONSIDERATION FOR ECONOMIC
C          CONDITIONS NEED BE TAKEN INTO ACCOUNT.)
   42 CF(4)=0
      GO TO 50
C
C        (EFLAG POSITIVE INDICATES THAT A "BUST" IS PROBABLY IN PROGRESS
C          AND THAT PRICES ARE LOW. IF STRENGTH IS NOT ESPECIALLY HIGH,
C          THIS IS A GOOD TIME TO ARM.)
   43 IF (SN.GT.4) GO TO 431
      S(4)=1
      CF(4)=P(4)
      GO TO 50
  431 J=MAXO(ATABN(2),ATABN(3))
      DO 432 I=2,3
      IF (J.EQ.ATABN(I)) GO TO 434
  432 CONTINUE
      WRITE (6,433)
  433 FORMAT (//,' *** S/R STRTGY ERROR #9 ***')
  434 S(4)=I
      CF(4)=P(4)
C
C        (NOW COMBINE ALL THE TERMS INTO THE POLYNOMIAL AND DETERMINE
C          STRATN BY A VOTING PROCESS.)
   50 PRBLS(1)=0
      PRBLS(2)=0
      PRBLS(3)=0
      DO 501 I=1,4
      IF (S(I).EQ.1) PRBLS(1)=PRBLS(1)+CF(I)
      IF (S(I).EQ.2) PRBLS(2)=PRBLS(2)+CF(I)
      IF (S(I).EQ.3) PRBLS(3)=PRBLS(3)+CF(I)
  501 CONTINUE
```

```
      J=MAXO(PRBLS(1),PRBLS(2),PRBLS(3))
      DO 502 I=1,3
      IF (J.EQ.PRBLS(I)) GO TO 504
  502 CONTINUE
      WRITE (6,503)
  503 FORMAT (//,' *** S/R STRTGY ERROR #11 ***')
      RETURN
  504 IF (PRBLS(1).EQ.PRBLS(2).OR.PRBLS(1).EQ.PRBLS(3).OR.
     1PRBLS(2).EQ.PRBLS(3)) GO TO 51
  505 STRATN=I
      RETURN
   51 IF (PRBLS(1).EQ.PRBLS(2)) GO TO 511
      IF (PRBLS(1).EQ.PRBLS(3)) GO TO 512
      IF (J.NE.PRBLS(2)) GO TO 505
      STRATN=MAXO(ATABN(2),ATABN(3))
      DO 510 K=2,3
      IF (STRATN.EQ.ATABN(K)) GO TO 5103
  510 CONTINUE
 5101 WRITE (6,5102)
 5102 FORMAT (//,' S/R STRTGY ERROR #12 ***')
      RETURN
 5103 STRATN=K
      RETURN
  511 IF (J.NE.PRBLS(1)) GO TO 505
      STRATN=MAXO(ATABN(1),ATABN(2))
      DO 5110 K=1,2
      IF(STRATN.EQ.ATABN(K)) GO TO 5103
 5110 CONTINUE
      GO TO 5101
  512 IF (J.NE.PRBLS(1)) GO TO 505
      STRATN=MAXO(ATABN(1),ATABN(3))
      DO 5120 K=1,3,2
      IF (STRATN.EQ.ATABN(K)) GO TO 5103
 5120 CONTINUE
      GO TO 5101
C        (THIS COMPLETES THE STRATEGY DECISION AND RECONSIDERATION
C          PHASES OF THIS SUBROUTINE.)
C
C
C        (THE THIRD FUNCTION OF THIS SUBROUTINE IS TO ANALYZE THE
C          RESULTS OF THE LAST MOVE AND DETERMINE IF A CORRECT CHOICE
C          OF STRATEGY WAS MADE. IF SO, WELL AND GOOD, BUT IF NOT
C          THE PARAMETERS P(I) ARE CHANGED TO REFLECT WHAT MAY HAVE
C          BEEN A BETTER CHOICE. ANALYSIS IS NOT DONE IF THE "EMERGENCY"
C          PROCEDURES OF STATEMENT 1 OF THIS SUBROUTINE ARE CARRIED OUT.)
C
   70 ANAL=0
C        (THIS RESETS THE ANAL FLAG.)
```

```
      RECON=-10
C
      J=MAXO(RTABN(1,STRATS),RTABN(2,STRATS),RTABN(3,STRATS))
      DO 71 I=1,3
      IF (J.EQ.RTABN(I,STRATS)) GO TO 72
   71 CONTINUE
      WRITE (6,711)
  711 FORMAT (//,' *** S/R ANAL ERROR ***')
   72 IF (STRATN.EQ.I) RETURN
C        (INDICATES SYSTEM PICKED BEST STRATEGY.)
      K=I
      GO TO (721,721,73),I
  721 K=K+1
      IF (J.EQ.RTABN(K,STRATS)) GO TO 722
C        (CHECK FOR TIES.)
      IF (STRATN.EQ.K) RETURN
      GO TO (721,721,73),K
  722 IF (STRATN.EQ.K) RETURN
      GO TO (721,721,73),K
C
C        (BRANCHING TO 73 INDICATES THAT A BETTER STRATEGY
C          COULD HAVE BEEN CHOSEN.)
   73 DO 7301 J=1,5
 7301 PRBLS(J)=0
      DO 730 J=1,4
      IF (I.EQ.S(J)) GO TO 74
  730 CONTINUE
      RETURN
C
   74 PRBLS(J)=J
  741 GO TO (75,75,75,76),J
   75 J=J+1
      IF (I.EQ.S(J)) GO TO 751
      PRBLS(J)=0
      GO TO 741
  751 PRBLS(J)=J
      GO TO 741
C
C        (THE SYSTEM HAS NOW DISCOVERED WHICH TERMS WERE CORRECT.
C          TUNING NOW COMMENCES.)
   76 DO 78 I=1,4
      IF (PRBLS(I).GT.0) GO TO 77
      IF (P(I).EQ.0) GO TO 78
      IF (CF(I).EQ.0) GO TO 78
      P(I)=P(I)-2
      GO TO 78
   77 P(I)=P(I)+2
   78 CONTINUE
```

```
      RETURN
      END


      SUBROUTINE ECALC(ENACT,ESACT)
      IMPLICIT INTEGER (A-W)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/EEE/EN,ES,TOPEN,TOPES
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
C
C     THE PURPOSE OF THIS SUBROUTINE IS TO DETERMINE THE WEIGHTED
C     EN (NORTH'S ESTIMATE OF SOUTH'S RELIABILITY) AND THE WEIGHTED
C     ES (NORTH'S ESTIMATE OF SOUTH'S ESTIMATE OF NORTH'S RELIABILITY).
C
C     KEY OF EACH MOVE'S EN/ES:
C      A.   50 ==> COMPLETELY TRUTHFUL                (CPS-STRATS= 0)
C      B.   10 ==> AGGRESSIVELY NOT TRUTHFUL BY 2     (CPS-STRATS=+2)
C      C.   20 ==> AGGRESSIVELY NOT TRUTHFUL BY 1     (CPS-STRATS=+1)
C      D.   30 ==> PASSIVELY NOT TRUTHFUL BY 2        (CPS-STRATS=-2)
C      E.   40 ==> PASSIVELY NOT TRUTHFUL BY 1        (CPS-STRATS=-1)
C
C     WEIGHTED EN OR ES IS DETERMINED FROM THE ABOVE STRAIGHT VALUES.
C     IT IS DETERMINED AS FOLLOWS:
C        1.  WEIGHTED EN = (6*(THIS MOVE'S STRAIGHT EN)
C                         + 3*(LAST WEIGHTED EN)
C                         + 1*(NEXT TO LAST WEIGHTED EN))/10
C        2.  IF PLAYER WAS NOT TRUTHFUL, BUT THE WEIGHTED EN FOR
C              THIS MOVE IS GREATER THAN FOR THE LAST MOVE,
C              SUBTRACT 10 FOR B, 8 FOR C, 4 FOR D, OR 2 FOR E
C                  (LETTERS REFER TO THE KEY ABOVE)
C              FROM THE PREVIOUS EN AND REFIGURE WEIGHTED
C              EN USING THIS VALUE AS THIS MOVE'S STRAIGHT EN IN
C              (1) ABOVE.  (THIS IS TO PREVENT A DISHONEST CPS
C              FROM ACTUALLY INCREASING THE WEIGHTED EN BECAUSE
C              OF THE WEIGHTS ASSIGNED TO EACH MOVE'S VALUE.)
C
C       (THE FIRST STEP IS TO INITIALLY BUILD THE EN AND ES DEQUES.)
      IF (NC.GT.1) GO TO 1
C
C       (FIRST, EN:)
      CALL GET3(L)
```

```
      DOWN3(L)=0
      NAME3(L)=50
      BOTEN=L
      RLINK3(L)=1
      CALL GET3(L)
      DOWN3(L)=BOTEN
      NAME3(L)=50
      MIDEN=L
      RLINK3(L)=3
      CALL GET3(L)
      DOWN3(L)=MIDEN
      TOPEN=L
      NAME3(L)=50
      RLINK3(L)=6
      EN=L
C       (THEN, ES:)
      CALL GET3(L)
      DOWN3(L)=0
      BOTES=L
      NAME3(L)=50
      RLINK3(L)=1
      CALL GET3(L)
      DOWN3(L)=BOTES
      NAME3(L)=50
      MIDES=L
      RLINK3(L)=3
      CALL GET3(L)
      DOWN3(L)=MIDES
      TOPES=L
      NAME3(L)=50
      ES=L
      RLINK3(L)=6
      IF (NC.EQ.1) RETURN
C
    1 NAME3(BOTEN)=NAME3(MIDEN)
      NAME3(MIDEN)=NAME3(TOPEN)
      NAME3(BOTES)=NAME3(MIDES)
      NAME3(MIDES)=NAME3(TOPES)
      J=CPS-STRATS+3
      K=CPN-STRATN+3
      GO TO (2,3,4,5,6),J
C
C       (SOUTH WAS PASSIVELY DISHONEST BY 2:)
    2 NAME3(TOPEN)=30
      J=4
      GO TO 10
C       (PASSIVELY DISHONEST BY 1:)
    3 NAME3(TOPEN)=40
```

```
      J=2
      GO TO 10
C       (COMPLETELY TRUTHFUL:)
    4 NAME3(TOPEN)=50
      GO TO 12
C       (AGGRESSIVELY DISHONEST BY 1:)
    5 NAME3(TOPEN)=20
      J=8
      GO TO 10
C       (AGGRESSIVELY DISHONEST BY 2:)
    6 NAME3(TOPEN)=10
      J=10
C
   10 EVAL=NAME3(TOPEN)
      ENACT=NAME3(TOPEN)
   11 E=(6*EVAL+3*NAME3(MIDEN)+NAME3(BOTEN))/10
      IF (E.LT.NAME3(MIDEN)) GO TO 15
      E=NAME3(MIDEN)-J
      GO TO 15
   12 E=(6*NAME3(TOPEN)+3*NAME3(MIDEN)+NAME3(BOTEN))/10
      ENACT=50
   15 NAME3(TOPEN)=E
C
      GO TO (21,22,23,24,25),K
C
   21 NAME3(TOPES)=30
      K=4
      GO TO 30
   22 NAME3(TOPES)=40
      K=2
      GO TO 30
   23 NAME3(TOPES)=50
      GO TO 32
   24 NAME3(TOPES)=20
      K=8
      GO TO 30
   25 NAME3(TOPES)=10
      K=10
C
   30 EVAL=NAME3(TOPES)
      ESACT=NAME3(TOPES)
   31 E=(6*EVAL+3*NAME3(MIDES)+NAME3(BOTES))/10
      IF (E.LT.NAME3(MIDES)) GO TO 35
      E=NAME3(MIDES)-K
      GO TO 35
   32 E=(6*NAME3(TOPES)+3*NAME3(MIDES)+NAME3(BOTES))/10
      ESACT=50
   35 NAME3(TOPES)=E
```

```
C
      RETURN
      END


      SUBROUTINE CPNDCN(MOV,INCNT,PCNTN,PCNTNM,INCNTR)
C
C     THIS SUBROUTINE DETERMINES THE CONCESSION POINT TO BE DECLARED
C     BY THE COMPUTER (NORTH), CPN. IT DOES THIS AFTER STRATN, THE
C     STRATEGY TO BE FOLLOWED, HAS BEEN DECIDED UPON BY S/R STRTGY.
C
      IMPLICIT INTEGER (A-W)
      COMMON/ENP/ENARRY(50),ESARRY(50)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/TDP4/SEQ(20),SCONTR
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/EEE/EN,ES,TOPEN,TOPES
      COMMON/ST/STRUE,LASTGO,NFLAG,TURN,ANAL,RECON
      COMMON/TDP9/TYPENU,TYPE1,TYSOU,TYNOR
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFFN,PMOVEN,PMOVES
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
C
C        (FIRST DECIDE IF NORTH'S RELIABILITY IS HIGH ENOUGH TO AFFORD
C          A NON-TRUTHFUL DECLARATION. IF NOT, USE A RANDOM NUMBER TO
C          DECIDE IF A FALSE DECLARATION SHOULD BE MADE ANYWAY. THIS
C          IS TO PREVENT BUILD-UP OF A PATTERN OF UNRELIABILITY.
C
      IF (NC.GT.2) GO TO 3
    5 CALL RANDOM
      IF (YRAND.GT.0.33) GO TO 1
    6 CPN=STRATN
      RETURN
    1 IF (YRAND.GT.0.67) GO TO 2
      CPN=2
      RETURN
    2 CPN=3
      RETURN
    3 IF (NC.GT.4) GO TO 10
      IF (DEFES.GT.0.OR.BDEFS.GT.0) GO TO 4
      CALL CLSMVN(MOV,INCNT,PCNTN,PCNTNM,INCNTR)
    4 IF (PMOVEN.EQ.0) GO TO 5
```

```
   25 CPN=PMOVEN
      RETURN
   10 TOPES=ES
      IF (NAME3(TOPES).GE.40) GO TO 20
      TOPES=DOWN3(TOPES)
      IF (NAME3(ES).LE.NAME3(TOPES)) GO TO 15
      TOPEN=TOPES
      TOPES=DOWN3(TOPES)
      IF (NAME3(TOPEN).GT.NAME3(TOPES)) GO TO 20
C       (GO AHEAD IF RELIABILITY INCREASING.)
   15 TOPEN=EN
      TOPES=ES
      CALL RANDOM
      IF (YRAND.LT.0.3) GO TO 20
      CPN=STRATN
      RETURN
   20 TOPEN=EN
      TOPES=ES
      IF (PMOVES.GT.0) GO TO 21
      NORSO=1
      CALL CLSTYP(NORSO)
   21 IF (PMOVEN.GT.0) GO TO 25
      CALL RANDOM
      IF (YRAND.LT.0.5) GO TO 6
      IF (STRATN.EQ.1) CPN=3
      IF (STRATN.EQ.2) CPN=2
      IF (STRATN.EQ.3) GO TO 5
      RETURN
      END


      SUBROUTINE RENEG(PROBLM,WHOCAL)
C
C     THIS SUBROUTINE IS CALLED UPON IF EITHER NORTH OR SOUTH WISH TO
C     RENEGOTIATE THE OTHER'S CONCESSION POINT CALLING FOR ARMING.
C
      IMPLICIT INTEGER (A-W)
      COMMON/ST/STRUE,LASTGO,NFLAG,TURN,ANAL,RECON
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
C
      IF (WHOCAL.EQ.1) GO TO 100
C      (A BRANCH INDICATES THAT THE PLAYER ASKED FOR RENEGOTIATION,
C       NO BRANCH INDICATES THAT THE COMPUTER ASKED.)
      GO TO (10,20,30),PROBLM
   10 WRITE (6,11)
   11 FORMAT (//,' OUR STRENGTHS AND MOVES SO FAR HAVE INDICATED THAT WE
```

```
     1 ARE CONDUCTING AN ARMS RACE.  A RENEGOTIATION IS REQUESTED.')
      WRITE (6,12)
   12 FORMAT (' AFTER RENOGOTIATING, WHAT IS YOUR NEW CONCESSION PT?')
      READ (5,13) CPS
   13 FORMAT (I1)
      RETURN
   20 WRITE (6,21)
   21 FORMAT (//,' IT IS REQUESTED THAT WE RENOGOTIATE. YOU HAVE ARMED
     1OVER 50% OF THE MOVES, AND IF THIS KEEPS UP, WE WILL BOTH GO BROKE
     2',/,'   CONDUCTING AN ARMS RACE.')
      WRITE (6,12)
      READ (5,13) CPS
      RETURN
   30 WRITE (6,31)
   31 FORMAT (//,' IT IS REQUESTED THAT WE RENOGOTIATE. YOU ARE ALREADY
     1 QUITE STRONG, YET YOU HAVE ARMED AT LEAST TWO OUT OF THE LAST',
     2/,'   THREE MOVES.')
      WRITE (6,12)
      READ (5,13) CPS
      RETURN
C
  100 CALL MAXSTR(MAXGN)
C        (THE PROGRAM ASKS FOR THE MAXIMUM GAIN STRATEGY IN ORDER TO
C          APPEASE THE PLAYER, YET BENEFIT AS MUCH AS POSSIBLE.)
      STRATN=MAXGN
      CALL RANDOM
      IF (YRAND.GT.0.8.AND.STRATN.EQ.1) STRATN=2
      CALL RANDOM
      IF (YRAND.GT.0.67) GO TO 110
      IF (YRAND.GT.0.33) GO TO 120
      CPN=STRATN
      GO TO 40
  110 CPN=2
      GO TO 40
  120 CPN=3
  40  WRITE (6,101) CPN
  101 FORMAT (//,' BASED ON YOUR REQUEST FOR RENEGOTIATION, I HAVE CONSI
     1DERED MY CONCESSION POINT. MY NEW CP IS TO:',I2,'.')
      WHOCAL=0
      RETURN
      END


      SUBROUTINE OPTSTR(STRATO)
C
C     THIS SUBROUTINE DETERMINES THE OPTIMUM STRATEGY BASED ON ZERO-SUM
C        TWO PERSON RECTANGULAR GAME THEORY. THE OPTIMUM STRATEGY IS
C        RETURNED BY THE PARAMETER STRATO.
```

```
C
      IMPLICIT INTEGER (A-W)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      DIMENSION Q(3),W(3)
C
C     THE SUBROUTINE FIRST DETERMINES IF A SADDLE POINT EXISTS.
C
      DO 10 I=1,3
      Q(I)= MINO(RTABN(I,1),RTABN(I,2),RTABN(I,3))
   10 W(I)= MAXO(RTABN(1,I),RTABN(2,I),RTABN(3,I))
      QMAX= MAXO(Q(1),Q(2),Q(3))
      WMIN= MINO(W(1),W(2),W(3))
      IF (QMAX.NE.WMIN) GO TO 30
      DO 11 I=1,3
      IF (QMAX.EQ.Q(I)) GO TO 13
   11 CONTINUE
      WRITE (6,12)
   12 FORMAT (//,' S/R OPTSTR ERROR #1 *****')
      STOP
   13 DO 14 J=1,3
      IF (WMIN.EQ.W(J))GO TO 22
   14 CONTINUE
      WRITE (6,15)
   15 FORMAT (//,' S/R OPTSTR ERROR #2 *****')
C
   22 L=I
   16 IF (RTABN(L,J).EQ.QMAX) GO TO 40
   17 IF (L.EQ.3) GO TO 19
      K=L+1
      DO 18 L=K,3
      IF (QMAX.EQ.Q(L))GO TO 16
   18 CONTINUE
   19 IF (J.EQ.3) GO TO 30
      J=J+1
      DO 20 L=J,3
      IF (WMIN.EQ.W(L))GO TO 21
   20 CONTINUE
      GO TO 30
   21 J=L
      GO TO 22
   40 STRATO=L
      RETURN
C
C     IF NO SADDLE POINT EXISTS, THE CONCEPT OF DOMINENCE IS USED TO
C       ATTEMPT TO REDUCE THE SIZE OF THE MATRIX.
C
```

```
   30 L=3
      I=1
      K=2
   31 IF (RTABN(I,1).GE.RTABN(K,1).AND.RTABN(I,2).GE.RTABN(K,2).AND.
     1RTABN(I,3).GE.RTABN(K,3)) GO TO 35
      GO TO 351
   35 IF (RTABN(I,1).GE.RTABN(L,1).AND.RTABN(I,2).GE.RTABN(L,2).AND.
     1RTABN(I,3).GE.RTABN(L,3)) GO TO 36
  351 GO TO (32,33,34),I
   32 I=2
      K=1
      GO TO 31
   33 I=3
      L=2
      GO TO 31
   36 STRATO=I
      RETURN
C
C     THE STMT 34 BRANCH INDICATES THAT NO OPTIMUM STRATEGY CAN BE
C     EASILY DETERMINED. IN THIS CASE, THE S/R RETURNS A STRATEGY
C     RECOMMENDATION BASED ON STRENGTH.
C
   34 IF (SN.LE.-2) GO TO 39
      STRATO=3
      RETURN
   39 STRATO=1
      RETURN
      END


      SUBROUTINE MAXSTR(MAXGN)
C
C     THIS SUBROUTINE DETERMINES THE MAXIMUM GAIN STRATEGY FROM THE
C     RELATIVE TABLE (RTABN) OF POINTS. THE SELECTED STRATEGY NUMBER
C     IS RETURNED BY PARAMETER MAXGN.
C
      IMPLICIT INTEGER (A-W)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RN,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2POLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      DIMENSION Q(3)
C
      DO 12 I=1,3
   12 Q(I)=MAXO(RTABN(I,1),RTABN(I,2),RTABN(I,3))
      MAXGN=MAXO(Q(1),Q(2),Q(3))
      DO 14 I=1,3
      IF (MAXGN.EQ.Q(I)) GO TO 13
   14 CONTINUE
```

```
      WRITE (6,1)
    1 FORMAT (//,' S/R MAXSTR ERROR ************')
      RETURN
   13 MAXGN=I
      RETURN
      END


      SUBROUTINE MINSTR(MINLCS)
C
C     THIS SUBROUTINE DETERMINES THE STRATEGY FOR MINIMUM RISK OF LOSS
C     OF POINTS RELATIVE TO THE OPPONENT. THE SELECTED STRATEGY IS
C     RETURNED BY THE PARAMETER MINLCS.
C
      IMPLICIT INTEGER (A-W)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      DIMENSION Q(3)
C
      DO 10 I=1,3
   10 Q(I)= MINO(RTABN(I,1),RTABN(I,2),RTABN(I,3))
      QMAX=MAXO(Q(1),Q(2),Q(3))
      DO 12 I=1,3
      IF (QMAX.EQ.Q(I)) GO TO 13
   12 CONTINUE
      WRITE (6,1)
    1 FORMAT (//,' S/R MINSTR ERROR ************')
      RETURN
   13 MINLOS=I
      RETURN
      END


      SUBROUTINE ECONMY
C
C     THIS SUBROUTINE DETERMINES IF THE STATE OF THE ECONOMY HAS CHANGED,
C     AND IF SO, ATTEMPTS TO DETERMINE THE ECONOMIC CONDITIONS AND SET A
C     FLAG (EFLAG) ACCORDINGLY.
C
C     THE ECONOMIC CONDITION IS RANDOMLY GENERATED AT RANDOM TIMES, BUT
C     THE AMOUNT OF CHANGE TO COSTS IS NOT FACTORED INTO THE TABLES, AND
C     HENCE IS UNKNOWN TO THE OPPONENTS (COMPUTER AND PLAYER).
C
      IMPLICIT INTEGER (A-W)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
```

```
C
      PCHG=PNOLD+RTABN(STRATN,STRATS)+FACTXN-PN
      IF (PCHG) 3,2,1
C
    1 EFLAG=-10
C       (INDICATES COSTS ARE EXPENSIVE - A BOOM)
      RETURN
C
    2 EFLAG=0
C       (INDICATES COSTS ARE NORMAL)
      RETURN
C
    3 EFLAG=10
C       (INDICATES COSTS ARE CHEAP - A BUST)
      RETURN
      END


      SUBROUTINE ENPAT(PTRUTH)
C
C     THE PURPOSE OF THIS SUBROUTINE IS TO DETERMINE PATTERNS IN THE
C     EN (NORTH'S ESTIMATE OF SOUTH'S RELIABILITY) ARRAY, IN ORDER TO
C     PREDICT THE TRUTHFULNESS OF SOUTH'S DECLARATION.
C
C        PTRUTH=0 ==> SOUTH'S DECLARATION IS PROBABLY NOT TRUE.
C        PTRUTH=1 ==> SOUTH'S DECLARATION IS PROBABLY TRUE.
C
      IMPLICIT INTEGER (A-W)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/ENP/ENARRY(50),ESARRY(50)
      COMMON/EEE/EN,ES,TOPEN,TOPES
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
C
      L=1
      IF (NC.GT.4) GO TO 5
      GO TO (1,2,3,4),NC
    1 CALL RANDOM
      IF (YRAND.GT.0.7) GO TO 101
C       (ASSUME 70% CHANCE OF TELLING THE TRUTH FIRST TIME.)
  100 PTRUTH=1
      GO TO 99
```

```
  101 PTRUTH=0
      GO TO 99
    2 IF (NAME3(EN).EQ.50) GO TO 100
      PTRUTH=0
      GO TO 99
    3 IF (NAME3(EN).EQ.50) GO TO 101
C       (IF HE HAS TOLD TRUTH THE 1ST 2 TIMES, ASSUME HE WILL NOT 3RD.)
      PTRUTH=1
      GO TO 99
    4 IF (NAME3(EN).EQ.50) GO TO 101
      IF (ENARRY(2).EQ.50.AND.ENARRY(3).EQ.50) GO TO 101
C       (ASSUME PATTERN OF 1-2-1 UNTRUTH/TRUTH/UNTRUTH.)
      PTRUTH=1
      GO TO 99
C
    5 IF (NAME3(EN).EQ.50) GO TO 100
C       (HAS HE ALWAYS TOLD TRUTH?)
      N=NC-1
      IF (ENARRY(N).EQ.50) GO TO 500
C       (IF TOLD TRUTH LAST TIME, DETERMINE PATTERN.)
      DO 6 I=2,N
      IF (ENARRY(NC-I).EQ.50) GO TO 75
C       (IF HE HAS EVER TOLD TRUTH, DETERMINE UNTRUTH PATTERN.)
    6 CONTINUE
      PTRUTH=0
      GO TO 99
C
   75 J=NC-I
      DO 76 I=J,N
      IF (ENARRY(NC-I).LT.50) GO TO 77
   76 CONTINUE
      PTRUTH=1
C       (HISTORY OF COMPLETE TRUTHFULNESS PRIOR LAST UNTRUTH, CAN NOT
C          DETERMINE UNTRUTH PATTERN, ASSUME TRUTH.)
      GO TO 99
   77 K=I-J
C       (K IS TRUTH PATTERN.)
      DO 78 I=K,N
      IF (ENARRY(NC-I).EQ.50) GO TO 79
   78 CONTINUE
      PTRUTH=0
C       (VERY POOR HONESTY DEMONSTRATED, ASSUME UNTRUTH.)
      GO TO 99
   79 L=I-J-K+1
C       (L IS UNTRUTH PATTERN.)
C       (PATTERN IS APPROXIMATELY K/L/K TRUTH/UNTRUTH/TRUTH.)
      I=J-1
      IF (I.GE.L) GO TO 100
```

```
C         (IS PATTERN OF UNTRUTHS SATISFIED?)
        PTRUTH=0
        GO TO 99
C
  500   DO 51 I=2,N
        IF (ENARRY(NC-I).LT.50) GO TO 52
   51   CONTINUE
        PTRUTH=1
C         (ASSUME HE MUST BE COMPLETELY HONEST.)
        GO TO 99
   52   IF (I.EQ.N) GO TO 101
C         (ASSUME HE IS AT END OF PATTERN.)
        J=I-1
C         (J IS NUMBER OF TRUTHS IN THIS SERIES.)
        I=I+1
        DO 53 L=I,N
        IF (ENARRY(NC-L).LT.50) GO TO 54
   53   CONTINUE
        PTRUTH=1
C         (HISTORY OF COMPLETE TRUTHFULNESS PRIOR LAST UNTRUTH ==> TRUTH.)
        GO TO 99
   54   K=L-I
C         (K IS TRUTH PATTERN LENGTH.)
        IF (J.GE.K) GO TO 101
C         (IS PATTERN OF TRUTHS SATISFIED?)
        PTRUTH=1
C
   99   CONTINUE
        RETURN
        END

        SUBROUTINE CATLOG
C
C         ***********************************************************
C         *                                                         *
C         *     THE TWENTY-FIVE SUBROUTINES WITHIN THIS SECTION     *
C         *     SUPPORT THE LEARNING CAPABILITIES OF THE PROGRAM.   *
C         *                                                         *
C         ***********************************************************
C
C
C
C
C       SUBROUTINE TO BUILD THE LIBRARY OF CATALOGUE OF PLAYERS.
C
        IMPLICIT INTEGER (A-W)
        COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
        COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
```

```
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      IF(CATLGN.GT.0) GOTO 101
      CATLGN=CATLGN+1
      CALL GET3(L)
C         FIRST PLAYER CELL
      TOP=L
      DOWN3(TOP)=0
      BOTM=TOP
      CATLG=TOP
      NAME3(TOP)=PLAYER
      GOTO 50
  101 CALL SEARCH(PLY)
C         CHECK TO SEE IF LISTED. IF IT IS MOVE PLAYER TO TOP OF CATLG.
      IF(PLY.EQ.1)GOTO 200
C         CHECK FOR 10 PLAYERS IN THE CATALOGUE. IF THERE IS DELETE THE
C         BOTTOM PLAYER.
      IF(CATLGN.EQ.10)GOTO 300
C
C     UPDATE THE NUMBER OF PLAYERS IN THE CATALOGUE COUNTER
      CATLGN=CATLGN+1
C
C     GET ADDITIONAL PLAYER CELL
C
  400 TOP=CATLG
      CALL GET3(L)
      DOWN3(L)=TOP
      TOP=L
      CATLG=TOP
      NAME3(TOP)=PLAYER
C
C     BUILD ADDITIONAL CELLS FOR EXPERIENCE LIBRARY ON NEW PLAYER.
C
   50 CALL GET4(J)
C
C     CELL FOR CHARACTERISTICS HEADER.
      RLINK3(TOP)=J
      CHAR=J
C     CELL FOR AGGRESSIVENESS HEADER
      CALL GET2(K)
      RLINK4(CHAR)=K
      AGGRS=K
      NAME2(AGGRS)=0
      DOWN2(AGGRS)=0
C     CELL FOR PARAMETERS
      CALL GET4(J)
```

```
      LLINK4(CHAR)=J
      PARAM=J
      NAME4(PARAM)=0
      RLINK4(PARAM)=0
      LLINK4(PARAM)=0
      DOWN4(PARAM)=0
C
      CALL GET4(J)
C
C     CELL FOR HISTORY HEADER
C
      DOWN4(CHAR)=J
      HIST=J
      NAME4(HIST)=0
      RLINK4(HIST)=0
      LLINK4(HIST)=0
      DOWN4(HIST)=0
C
C     CELL FOR RELIABILITY REFERENCE
C
      CALL GET2(K)
      NAME4(CHAR)=K
      ENPTR=K
      NAME2(ENPTR)=0
      DOWN2(ENPTR)=0
      RETURN
C
C     GET SUBROUTINE TO DELETE A PLAYER FROM THE BOTTOM OF CATALOGUE.
C
  300 CALL DELETP
      GOTO 400
C
C GET SUBROUTINE TO MOVE EXISTING PLAYER TO THE TOP OF THE CATALOGUE
  200 CALL MOVEPL
C
      RETURN
      END


      SUBROUTINE DELETP
C
C     SUBROUTINE TO DELETE A PLAYER FROM THE BOTTOM OF THE CATALOGUE.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/TDP4/SEQ(20),SCONTR
```

```
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      IF(RLINK3(BOTM).EQ.0) GOTO 10
C
C     RETURN CELL TO AVAIL2 LIST FROM ENPTR
C
      CHAR=RLINK3(BOTM)
      K2=NAME4(CHAR)
      DOWN2(K2)=RLINK4(CHAR)
      DOWN2(RLINK4(CHAR))=AVAIL2
      AVAIL2=K2
C
C     RETURNS CELLS TO AVAIL4 FROM CHAR AND HIST.
C
      HIST=DOWN4(CHAR)
      CALL DSEQLB
      PARAM=LLINK4(CHAR)
      DOWN4(HIST)=PARAM
      DOWN4(PARAM)=AVAIL4
      AVAIL4=CHAR
   10 TOP=CATLG
C
C     RETURNS PLAYER CELL TO AVAIL3
C
   11 IF(DOWN3(TOP).EQ.BOTM) GOTO 12
      TOP=DOWN3(TOP)
      GO TO 11
   12 DOWN3(BOTM)=AVAIL3
      AVAIL3=BOTM
      BOTM=TOP
      DOWN3(BOTM)=0
      RETURN
      END


      SUBROUTINE INTLIB(INCNT,MOVE,TOPI,INCNTR,MOV)
C
C     INITIAL STRATEGY LIBRARY. THIS SUBROUTINE SETS UP CELLS FOR THE
C     INITIAL STRATEGY LIBRARY OF CELLS.
C
      IMPLICIT INTEGER (A-W)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
```

```
      COMMON/TDP3/TYPE(20),INIT(20)
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DATA A1/'A1'/,A2/'A2'/
C
C    "INCNT" IS THE COUNT OF CELLS IN THE LIBRARY. "INCNTR" IS THE
C     ALLOWABLE NUMBER OF CELLS IN THE LIBRARY. (IE. INITIALLY 10 CELLS
C     WERE THE MAXIMUM ALLOWED)."MOV" INDICATES WHETHER THE INITIAL
C     MOVES ARE IN THE LIBRARY OR IF A NEW CELL IS REQUIRED.
C
      IF(INCNT.EQ.INCNTR) GOTO 10
      INCNT=INCNT+1
      CALL GET4(J)
      INIT(INCNT)=J
      TOPI=J
      RETURN
   10 CALL DINTLB(INCNT,MOVE,TOPI)
      RETURN
      END


      SUBROUTINE DINTLB(INCNT,MOVE,TOPI)
C
C     SUBROUTINE TO DELETE OR COMBINE SIMILAR ELEMENTS IN
C     THE INITIAL MOVE LIBRARY.
C
      IMPLICIT INTEGER (A-W)
      COMMON/JEC/VALUE(7,3),RTARN(3,3),RTABS(3,3),ATARN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP/MOVES,MOVEN
      COMMON/TDP3/TYPE(20),INIT(20)
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DATA A1/'A1'/,A2/'A2'/
C     SUBROUTINE TO DELETE OR COMBINE INITIAL MOVES LIBRARY.
      IF(MOVE.EQ.MOVEN) GOTO 20
      IF(NAME4(HIST).EQ.0) GOTO 11
      TOPI=NAME4(HIST)
    8 VAL20=TOPI
      RUNTOP=TOP
   15 IF(RUNTOP.EQ.BOTM) GOTO 13
```

```
      RUNTOP=DOWN3(RUNTOP)
      CHARR=RLINK3(RUNTOP)
      HISTR=DOWN4(CHARR)
      IF(MOVE.EQ.MOVEN) GOTO 22
      IF(NAME4(HISTR).EQ.VAL20) GOTO 14
      GOTO 15
13    TOPMN=MOVE
      NAME4(TOPI)=NAME2(TOPMN)
      TOPMN=DOWN2(TOPMN)
      RLINK4(TOPI)=NAME2(TOPMN)
      TOPMN=DOWN2(TOPMN)
      LLINK4(TOPI)=NAME2(TOPMN)
      DOWN4(TOPI)=0
      RETURN
14    NAME4(HISTR)=0
      GOTO 15
11    MCNT=1
12    TOPI=INIT(MCNT)
      IF(MCNT.EQ.INCNT) GOTO 100
      RUNTOP=TOP
      VAL20=TOPI
      GOTO 15
20    IF(RLINK4(HIST).EQ.0) GOTO 21
      TOPI=RLINK4(HIST)
      GOTO 8
21    MCNT=2
      GOTO 12
22    IF(RLINK4(HIST).EQ.VAL20) GOTO 24
      GOTO 15
24    RLINK4(HIST)=0
      GOTO 15
100   RETURN
      END


      SUBROUTINE TYPELB(INCNTR,WON,INCNT)
C
C     SUBROUTINE TO BUILD NEW STRUCTURES IN THE TYPE LIBRARY AT THE
C     END OF A GAME.
C
      IMPLICIT INTEGER (A-W)
      COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CONTR
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP4/SEQ(20),SCONTR
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/TDP8/RLHIST,NAHIST
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFEN,PMOVEN,PMOVES
```

```
      COMMON/TPJEC/DONOR,DOSOU,CKCNT1,CKCNT2
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,FFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DATA A1/'A1'/,A2/'A2'/
      CKCNT1=0
      CKCNT2=0
      DOSOU=0
      DONOR=0
      NAME4(HIST)=NAHIST
      RLINK4(HIST)=RLHIST
      IF(NC.LT.10)GOTO 101
      IF(CONTR.EQ.INCNTR) GOTO 100
3     STRTP=LLINK4(PATRNS)
8     TOPGP=DOWN4(STRTP)
      RTOP=TOPGP
      CONT=1
9     IF(CONT.EQ.INCNTR) GOTO 500
      IF(DOWN2(RTOP).EQ.0)GOTO 500
      RTOP=DOWN2(RTOP)
      CONT=CONT+1
      GOTO 9
500   CONTR=CONTR+1
      CALL GET3(L)
      TYPE(CONTR)=L
      TOPSN=L
      RTOP1=RTOP
6     IF(DOWN2(RTOP1).EQ.0) GOTO 7
      RTOP1=DOWN2(RTOP1)
      GOTO 6
7     IF(DOWN2(RTOP).EQ.0)GOTO 4
      DOWN2(RTOP1)=AVAIL2
      AVAIL2=DOWN2(RTOP)
 4    DOWN2(RTOP)=0
      DOWN3(TOPSN)=TOPGP
      DOWN4(STRTP)=0
C     CHECK TO SEE IF BOTH NORTH AND SOUTH TYPE LIBRARY MEMORY IS SETUP.
      IF(STRTP.EQ.LLINK4(PATRNN))GOTO 50
      TOPS=L
      IF(DONOR)2,2,102
2     STRTP=LLINK4(PATRNN)
      GOTO 8
50    TOPN=L
51    IF(WON)11,12,13
```

```
11   NAME3(TOPS)=0
     RLINK3(TOPS)=TOPN
     NAME3(TOPN)=TOPS
     RLINK3(TOPN)=0
     GOTO 40
12   NAME3(TOPS)=0
     RLINK3(TOPS)=0
     TOPN=TOPS
     DOWN2(RTOP)=AVAIL2
     AVAIL2=DOWN3(TOPSN)
     DOWN3(TOPSN)=AVAIL3
     AVAIL3=TOPSN
     INITN=RLHIST
     DOWN4(INITN)=AVAIL4
     AVAIL4=INITN
     INCNT=INCNT-1
     CONTR=CONTR-1
     GOTO 40
13   NAME3(TOPN)=0
     RLINK3(TOPN)=TOPS
     NAME3(TOPS)=TOPN
     RLINK3(TOPS)=0
40   INITS=NAME4(HIST)
     DOWN4(INITS)=TOPS
     INITN=RLINK4(HIST)
     DOWN4(INITN)=TOPN
     RETURN
100  CALL DTYPLB
     IF(CKCNT1)333,331,331
333  DOSOU=-1
     GOTO 330
331  TOPS=DOWN4(NAME4(HIST))
330  IF(CKCNT2)334,335,336
334  DONOR=-1
     GOTO 337
336  DONOR=1
337  IF(DOSOU)3,200,200
200  IF(DONOR)2,102,102
335  WRITE(6,401)
401  FORMAT(5X,' THERE IS A MISTAKE IN DELETION OF A TYPE LIBRARY.')
102  TOPN=DOWN4(RLINK4(HIST))
     GOTO 51
101  RETURN
     END
```

```
      SUBROUTINE DTYPLB
C
C     SOBROUTINE TO DELET OR COMBINE STRUCTURES IN THE
C     TYPE LIBRARY.
C
      IMPLICIT INTEGER (A-W)
      COMMON/TDP4/SEQ(20),SCONTR
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,FFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFFN,PMOVEN,PMOVES
      COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CONTR
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP/MOVES,MOVEN
      COMMON/TPJEC/DONOR,DOSOU,CKCNT1,CKCNT2
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DATA A1/'A1'/,A2/'A2'/
    1 PATRN=PATRNS
      TOPI=NAME4(HIST)
    2 FLAG=1
      CONT=1
      CONT2=1
      STRTP=LLINK4(PATRN)
      MOVE=DOWN4(STRTP)
      TOPM=DOWN3(TYPE(CONT))
  101 IF(DOWN2(TOPM).EQ.0) GOTO 10
      IF(DOWN2(MOVE).EQ.0) GOTO 10
      CKGRP1=NAME2(TOPM)
      CKGRP2=NAME2(MOVE)
      CALL CKTYP(CKGRP1,CKGRP2,NOGO,FLAG)
      IF(NOGO.EQ.0) GOTO 20
      CONT2=CONT2+1
      FLAG=0
   20 IF(CONT2.EQ.4) GOTO 30
      TOPM=DOWN2(TOPM)
      MOVE=DOWN2(MOVE)
      FLAG=1
      GOTO 101
   10 DOWN4(TOPI)=TYPE(CONT)
      IF(PATRN.EQ.PATRNN) GOTO 880
      PATRN=PATRNN
      TOPI=RLINK4(HIST)
      GOTO 2
```

```
30    IF(CONT.EQ.CONTR) GOTO 40
      CONT=CONT+1
      GOTO 2
40    CONT=1
      MCNT=1
      TOPT=TYPE(CONT)
41    TOPI=INIT(MCNT)
      IF(DOWN4(TOPI).EQ.TOPT) GOTO 60
      IF(MCNT.EQ.INCNT) GOTO 61
      MCNT=MCNT+1
      GOTO 41
60    IF(PATRN.EQ.PATRNN) GOTO 45
      RTOP=CATLG
      RTOP1=RLINK3(RTOP)
      TOPD=NAME4(DOWN4(RTOP1))
44    IF(TOPI.EQ.TOPD) GOTO 46
42    IF(RTOP.EQ.BOTM) GOTO 47
      RTOP=DOWN3(RTOP)
      RTOP1=RLINK3(RTOP)
      GOTO 44
46    IF(PATRN.EQ.PATRNN) GOTO 43
      NAME4(DOWN4(RTOP1))=0
      GOTO 42
43    RLINK4(DOWN4(RTOP1))=0
      GOTO 42
47    DOWN4(TOPI)=AVAIL4
      AVAIL4=TOPI
      CNTI1=MCNT
      CNTI2=CNTI1+1
38    IF(CNTI1.EQ.INCNT) GOTO 37
      INIT(CNTI1)=INIT(CNTI2)
      CNTI1=CNTI1+1
      CNTI2=CNTI2+1
      GOTO 38
37    INCNT=INCNT-1
      IF(PATRN.EQ.PATRNN) GOTO 61
45    RTOP=CATLG
      RTOP1=RLINK3(RTOP)
      TOPD=RLINK4(DOWN4(RTOP1))
      GOTO 44
61    RTOP=DOWN3(TOPT)
      BTM=RTOP
63    IF(DOWN2(BTM).EQ.0) GOTO 62
      BTM=DOWN2(BTM)
      GOTO 63
62    DOWN2(BTM)=AVAIL2
      AVAIL2=RTOP
      DOWN3(TOPT)=AVAIL3
```

```
      AVAIL3=TOPT
      MCT1=CONT
      MCT2=MCT1+1
      IF(MCT1.EQ.CONTR) GOTO 57
620   TYPE(MCT1)=TYPE(MCT2)
      IF(MCT2.EQ.CONTR) GOTO 57
      MCT1=MCT1+1
      MCT2=MCT2+1
      GOTO 620
57    CONTR=CONTR-1
      IF(PATRN.EQ.PATRNN) GOTO 570
      CKCNT1=-1
      GOTO 572
570   CKCNT2=-1
572   SCNT=1
58    TOPS=SEQ(SCNT)
      DTOPS=TOPS
      DTOP1=DTOPS
59    DTOP2=DOWN3(DTOPS)
      TOPT2=NAME3(DTOPS)
      IF(TOPT.EQ.TOPT2) GOTO 64
      DTOP1=DTOPS
      IF(DOWN3(DTOPS).EQ.0) GOTO 65
      DTOPS=DOWN3(DTOPS)
      GOTO 59
65    IF(SCNT.EQ.SCONTR) GOTO 66
      SCNT=SCNT+1
      GOTO 58
64    IF(DOWN3(DTOPS).EQ.0) GOTO 67
      IF(DTOPS.EQ.TOPS) GOTO 68
      DOWN3(DTOP1)=DTOP2
      DOWN3(DTOPS)=RLINK3(DTOPS)
      DOWN3(RLINK3(DTOPS))=AVAIL3
      AVAIL3=DTOPS
      DTOPS=DTOP2
      GO TO 59
68    RTP=DTOP2
69    IF(DOWN3(DTOP2).EQ.0) GOTO 70
      RTP=DTOP2
      DTOP2=DOWN3(DTOP2)
      GOTO 69
70    NAME3(DTOPS)=NAME3(DTOP2)
      NAME3(RLINK3(DTOPS))=NAME3(RLINK3(DTOP2))
      RLINK3(RLINK3(DTOPS))=RLINK3(RLINK3(DTOP2))
      DOWN3(RLINK3(DTOPS))=DOWN3(RLINK3(DTOP2))
      DOWN3(RLINK3(DTOP2))=AVAIL3
      DOWN3(DTOP2)=RLINK3(DTOP2)
      AVAIL3=DOWN3(RTP)
```

```
      DOWN3(RTP)=0
      GOTO 59
67    IF(DTOPS.EQ.TOPS) GOTO 71
      DOWN3(DTOPS)=RLINK3(DTOPS)
      DOWN3(RLINK3(DTOPS))=AVAIL3
      AVAIL3=DOWN3(DTOP1)
      DOWN3(DTOP1)=0
      GOTO 65
71    RUNT=CATLG
72    CHARR=RLINK3(RUNT)
      HISTR=DOWN4(CHARR)
      IF(TOPS.EQ.LLINK4(HISTR)) GOTO 710
7200  IF(TOPS.EQ.DOWN4(HISTR)) GOTO 720
73    IF(RUNT.EQ.BOTM) GOTO 730
      RUNT=DOWN3(RUNT)
      GOTO 72
710   LLINK4(HISTR)=0
      GOTO 7200
720   DOWN4(HISTR)=0
      GOTO 73
730   DOWN3(DTOPS)=RLINK3(DTOPS)
      DOWN3(RLINK3(DTOPS))=AVAIL3
      AVAIL3=DTOPS
      CT1=SCNT
      CT2=SCNT+1
      IF(CT1.EQ.SCONTR)GOTO 80
731   SEQ(CT1)=SEQ(CT2)
      IF(CT2.EQ.SCONTR) GOTO 80
      CT1=CT1+1
      CT2=CT2+1
      GOTO 731
80    SCONTR=SCONTR-1
      GOTO 65
880   CKCNT2=1
      RETURN
66    IF(PATRN.EQ.PATRNN) GOTO 660
      PATRN=PATRNN
      GOTO 2
660   RETURN
      END

      SUBROUTINE SEQLB(INCNTR,WON)
C
C     SUBROUTINE TO BUILD THE SEQUENCE LIBRARY.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
```

```
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP2/STK(10),STKM(10),STKN(10),STKNM(10)
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/TDP4/SEQ(20),SCONTR
      COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CCNTR
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFFN,PMOVEN,PMOVES
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DATA A1/'A1'/,A2/'A2'/
      PASN=-1
      IF(NC.LT.10)GOTO 401
      CNT=1
      PSN1=0
      SQCNTR=INCNTR+10
      IF(SCONTR.GT.SQCNTR) GOTO 100
   14 IF(LLINK4(HIST).EQ.0)GOTO 399
      TOPSQ=LLINK4(HIST)
      INITS=NAME4(HIST)
   15 RTOP=TOPSQ
      TYPENO=DOWN4(INITS)
   11 IF(NAME3(RTOP).EQ.TYPENO) GOTO 400
      IF(DOWN3(RTOP).EQ.0) GOTO 10
      RTOP=DOWN3(RTOP)
      CNT=CNT+1
      GOTO 11
   10 IF(CNT.GE.INCNTR) GOTO 1010
      CALL GET3(L)
C
      DOWN3(RTOP)=L
   16 RTOP=L
      DOWN3(RTOP)=0
      NAME3(RTOP)=TYPENO
      CALL GET3(L)
      RLINK3(RTOP)=L
      IMOVES=L
      NAME3(IMOVES)=NAME4(INITS)
      RLINK3(IMOVES)=RLINK4(INITS)
      DOWN3(IMOVES)=LLINK4(INITS)
      GOTO 400
  399 INITS=NAME4(HIST)
      TYPENO=DOWN4(INITS)
      GOTO 104
  400 INITS=RLINK4(HIST)
```

```
      TYPENO=DOWN4(INITS)
      IF(DOWN4(HIST).EQ.0)GOTO 104
      IF(PSN1)1C1,103,101
  103 TOPSQ=DOWN4(HIST)
      INITS=RLINK4(HIST)
      CNT=1
      PASN=9999
      PSN1=1
      GOTO 15
  104 IF(LLINK4(HIST).EQ.0) GOTO 402
      TOPSQ=LLINK4(HIST)
      CALL GET3(L)
      SCONTR=SCONTR+1
      SEQ(SCONTR)=L
      DOWN4(HIST)=L
      CNT=INCNTR
      PASN=9999
      GOTO 16
  402 CALL GET3(L)
      SCONTR=SCONTR+1
      SEQ(SCONTR)=L
      LLINK4(HIST)=L
      CNT=INCNTR
      PASN=0
      GOTO 16
 1010 PASN=-1
  101 IF(PASN)1,2,3
    2 GOTO 1C4
    3 RETURN
    1 CALL DSEQLB
      GOTO 14
  100 CALL DSEQLB
      GOTO 14
  401 RETURN
      END

      SUBROUTINE DSEQLB
C
C     SUBROUTINE TO DELETE THE SEQUENCE STRUCTURES OF A PLAYER
C     AND THE SEQUENCE STRUCTURES FOR THE ASSOCIATED COMPUTER
C     PATTERNS OF PLAY.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP2/STK(10),STKM(10),STKN(10),STKNM(10)
      COMMON/TDP4/SEQ(20),SCONTR
```

```
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFEN,PMOVEN,PMOVES
      COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CONTR
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DATA A1/'A1'/,A2/'A2'/
      IF(LLINK4(HIST)) 7,7,8
    8 TOPS=LLINK4(HIST)
   10 DTOP=TOPS
      DTOP1=DTOP
2     IF(DOWN3(DTOP).EQ.0) GOTO 11
      IF(DTOP.EQ.TOPS) GOTO 11
      DTOP=DOWN3(DTOP)
      DOWN3(DTOP1)=RLINK3(DTOP1)
      DTOP1=DOWN3(DTOP1)
      DOWN3(DTOP1)=DTOP
      DTOP1=DTOP
      GOTO 2
11    DOWN3(DTOP)=RLINK3(DTOP)
      DTOP=DOWN3(DTOP)
      DOWN3(DTOP)=AVAIL3
      AVAIL3=TOPS
      IF(TOPS.EQ.DOWN4(HIST))GOTO 20
7     IF(DOWN4(HIST))20,20,9
9     TOPS=DOWN4(HIST)
      GOTO 10
20    RETURN
      END

      SUBROUTINE PATRN
C
C     SUBROUTINE TO BUILD THE TEMPORARY MEMORY HEADER NODES FOR
C     BOTH THE PLAYER (PATRNS) AND THE COMPUTER (PATRNN).
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFEN,PMOVEN,PMOVES
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CONTR
```

```
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DATA A1/'A1'/,A2/'A2'/
      PATRNS=1
      PATRNN=1
      CALL GET4(J)
C
C     GET HEADER CELL FOR PATERN MEMORY OF SOUTH.
C
      PATRNS=J
      TOPS=J
      NAME4(TOPS)=0
      RLINK4(TOPS)=0
C
C     GET HEADER CELL FOR GROUP MOVES THIS GAME.FOR SOUTH
C
      CALL GET4(J)
      LLINK4(TOPS)=J
      STRTP=J
      NAME4(STRTP)=0
      RLINK4(STRTP)=0
      LLINK4(STRTP)=0
      DOWN4(STRTP)=0
      DOWN4(TOPS)=0
      CALL GET4(J)
C
C     GET HEADER CELL FOR PATTERN MEMORY OF NORTH.
C
      PATRNN=J
      TOPN=J
      NAME4(TOPN)=0
      RLINK4(TOPN)=0
C
C     GET HEADER CELL FOR GROUP MOVES THIS GAME FOR NORTH
C
      CALL GET4(J)
      LLINK4(TOPN)=J
      STRTPN=J
      NAME4(STRTPN)=0
      RLINK4(STRTPN)=0
      LLINK4(STRTPN)=0
      DOWN4(STRTPN)=0
      DOWN4(TOPN)=0
      RETURN
      END
```

```
      SUBROUTINE DPATNS
C
C     SUBROUTINE TO DELETE THE REMAINING NODES IN TEMPORARY
C     MEMORY AT THE END OF THE GAME.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP2/STK(10),STKM(10),STKN(10),STKNM(10)
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      WRITE(6,9)
    9 FORMAT(' DPATNS  '/)
      PATRN=PATRNS
   20 STRTP=LLINK4(PATRN)
      IF(DOWN4(STRTP).EQ.0)GOTO 10
      TOPGP=DOWN4(STRTP)
   12 IF(DOWN2(TOPGP).EQ.0)GOTO 11
      TOPGP=DOWN2(TOPGP)
      GOTO 12
   11 DOWN2(TOPGP)=AVAIL2
      AVAIL2=DOWN4(STRTP)
      DOWN4(STRTP)=0
   10 IF(DOWN4(PATRN).EQ.0)GOTO 13
      MOVE=DOWN4(PATRN)
   15 IF(DOWN2(MOVE).EQ.0)GOTO 14
      MOVE=DOWN2(MOVE)
      GOTO 15
   14 DOWN2(MOVE)=AVAIL2
      AVAIL2=DOWN4(PATRN)
      DOWN4(PATRN)=STRTP
      DOWN4(STRTP)=AVAIL4
      AVAIL4=PATRN
   13 IF(PATRN.EQ.PATRNN)GOTO 55
      PATRN=PATRNN
      GOTO 20
   55 RETURN
      END


      SUBROUTINE PATUPD
C
C
C     SJBROUTINE TO UPDATE TEMPORARY MEMORY OF BOTH NORTH (PATRNN)
C     AND SOUTH (PATRNS)
C
```

```
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/TDP/MOVES,MOVEN
      COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CONTR
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFFN,PMOVEN,PMOVES
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,FFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,FCNXS,PN,PS,FACTXN,FACTXS
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      TOPN=PATRNN
      TOPS=PATRNS
      IF(NC.GT.3) GOTO 1
      IF(DOWN4(TOPS).EQ.0) GOTO 10
      TOPMS=DOWN4(TOPS)
8     IF(DOWN2(TOPMS).EQ.0) GOTO 5
      TOPMS=DOWN2(TOPMS)
      GOTO 8
5     CALL GET2(K)
      DOWN2(TOPMS)=K
      TOPMS=DOWN2(TOPMS)
      NAME2(TOPMS)=STRATS
      DOWN2(TOPMS)=0
      STRAT=1
      CALL STRTOT(STRAT)
      IF(NC.EQ.3) GOTO 4
      GOTO 20
10    CALL GET2(K)
      DOWN4(TOPS)=K
      MOVES=K
      TOPMS=MOVES
      DOWN2(TOPMS)=0
      NAME2(TOPMS)=STRATS
      STRAT=1
      CALL STRTOT(STRAT)
      GOTO 20
4     TOPMS=MOVES
      MOVE=MOVES
      BYPASS=0
C
C     TOTAL VALUE OF THREE MOVES TO DETERMINE THE GROUP THEY BELONG TO.
C
      CALL TOTALM(MOVE,TOTRUE,BYPASS,INCNT,MCNT,TOTAL,TOTAL2)
      TMOVES=TOTAL2
```

```
      CALL TOTMV(TOTAL,GROUP)
      STRTP=LLINK4(TOPS)
      TOPGPS=STRTP
      IF(DOWN4(TOPGPS).EQ.0)GOTO 25
      TOPGPS=DOWN4(TOPGPS)
   27 IF(DOWN2(TOPGPS).EQ.0)GOTO 26
      TOPGPS=DOWN2(TOPGPS)
      GOTO 27
   25 CALL GET2(K)
      DOWN4(TOPGPS)=K
      TOPGPS=K
      DOWN2(TOPGPS)=0
      NAME2(TOPGPS)=GROUP
      GOTO 20
   26 CALL GET2(K)
      DOWN2(TOPGPS)=K
      TOPGPS=K
      NAME2(TOPGPS)=GROUP
      DOWN2(TOPGPS)=0
      GOTO 20
C     DELETE OLDEST OF THREE MOVES ADD LAST MOVE TO BOTH NORTH AND SOUTH
    1 TOPMS=MOVES
      TOPMN=MOVEN
   31 PT=DOWN2(TOPMS)
      NAME2(TOPMS)=NAME2(PT)
      IF(DOWN2(PT).EQ.0) GOTO 30
      TOPMS=DOWN2(TOPMS)
      GOTO 31
   30 NAME2(PT)=STRATS
      STRAT=1
      CALL STRTOT(STRAT)
C
C     SHIFT NEW MOVE INTO BOTTOM OF NORTHS MOVE PATTERN AND UPDATE TOTAL
C     HEADER.
C
   32 PT=DOWN2(TOPMN)
      NAME2(TOPMN)=NAME2(PT)
      IF(DOWN2(PT).EQ.0) GOTO 35
      TOPMN=DOWN2(TOPMN)
      GOTO 32
   35 NAME2(PT)=STRATN
      STRAT=0
      CALL STRTOT(STRAT)
      GOTO 4
   20 IF(NC.GT.3) GOTO 104
      IF(DOWN4(TOPN).EQ.0) GOTO 110
      TOPMN=DOWN4(TOPN)
  108 IF(DOWN2(TOPMN).EQ.0) GOTO 105
```

```
      TOPMN=DOWN2(TOPMN)
      GOTO 108
  105 CALL GET2(K)
      DOWN2(TOPMN)=K
      TOPMN=DOWN2(TOPMN)
      DOWN2(TOPMN)=0
      NAME2(TOPMN)=STRATN
      STRAT=0
      CALL STRTOT(STRAT)
      IF(NC.EQ.3) GOTO 104
      RETURN
  110 CALL GET2(K)
      DOWN4(TOPN)=K
      MOVEN=K
      TOPMN=MOVEN
      DOWN2(TOPMN)=0
      NAME2(TOPMN)=STRATN
      STRAT=0
      CALL STRTOT(STRAT)
      RETURN
  104 MOVEN=DOWN4(PATRNN)
      MOVE=MOVEN
      BYPASS=0
      CALL TOTALM(MOVE,TOTRUE,BYPASS,INCNT,MCNT,TOTAL,TOTAL2)
      TMOVEN=TOTAL2
      CALL TOTMV(TOTAL,GROUP)
      STRTP=LLINK4(TOPN)
      TOPGPN=STRTP
      IF(DOWN4(TOPGPN).EQ.0) GOTO 125
      TOPGPN=DOWN4(TOPGPN)
  127 IF(DOWN2(TOPGPN).EQ.0) GOTO 126
      TOPGPN=DOWN2(TOPGPN)
      GOTO 127
  125 CALL GET2(K)
      DOWN4(TOPGPN)=K
      TOPGPN=K
      DOWN2(TOPGPN)=0
      NAME2(TOPGPN)=GROUP
      RETURN
  126 CALL GET2(K)
      DOWN2(TOPGPN)=K
      TOPGPN=K
      NAME2(TOPGPN)=GROUP
      DOWN2(TOPGPN)=0
      RETURN
      END
```

```
      SUBROUTINE REMEMB(INCNT,INCNTR)
C
C     SUBROUTINE TO RECONSTRUCT PERMANENT MENORY PRIOR TO
C     A NEW GAME OR SERIES OF GAMES.
C
      IMPLICIT INTEGER (A-W)
      COMMON/TDJE/APN,APS,STACK(40)
      COMMON/PAR/P(4),S(4),PRBLS(5)
      COMMON/EEE/EN,ES,TOPEN,TOPES
      COMMON/ENP/ENARRY(50),ESARRY(50)
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFFN,PMOVEN,PMOVES
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/ST/STRUE,LASTGO,NFLAG,TURN,ANAL,RECON
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP2/STK(10),STKM(10),STKN(10),STKNM(10)
      COMMON/TDP8/RLHIST,NAHIST
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/TDP4/SEQ(20),SCONTR
      COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CONTR
      DIMENSION COMPN(3,3)
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DATA HEADS/'HEAD'/,TAILS/'TAIL'/,YES/'YES'/,NO/' NO'/
      DATA A1/'A1'/,A2/'A2'/
      WRITE(6,137)
  137 FORMAT ('   DO YOU WISH TO READ MEMORY AND REBUILD THE HISTORY OF
     1 PLAYERS, YES OR NO "A3" FORMAT RIGHT JUSTIFIED')
      READ(5,695)DU
 695  FORMAT (A3)
      IF(DU.EQ.NO) GOTO 27
      READ(2,459)TSTK,(STACK(I),I=1,TSTK)
  459 FORMAT(I3,20I3)
      READ(2,101)BUILD,INCNT,INCNTR,CONTR,SCONTR,APN,APS
  101 FORMAT(7I3)
      CALL REBILD(INCNT)
      CATLGN=0
   10 IF(CATLGN.EQ.BUILD) GOTO 22
      READ(2,102,END=50)PLAYER,NEM,DEM,NAG,DAG,NAP,RPA,LPA,DPA,NHIS,
     1PHIS,LHIS,DHIS
  102 FORMAT(A4,12I3)
      CALL CATLOG
      ENPTR=NAME4(CHAR)
      AGGRS=RLINK4(CHAR)
```

```
      PARAM=LLINK4(CHAR)
      NAME2(ENPTR)=NEM
      DOWN2(ENPTR)=DEM
      NAME2(AGGRS)=NAG
      DOWN2(AGGRS)=DAG
      NAME4(PARAM)=NAP
      RLINK4(PARAM)=RPA
      LLINK4(PARAM)=LPA
      DOWN4(PARAM)=DPA
      NAME4(HIST)=NHIS
      RLINK4(HIST)=RHIS
      LLINK4(HIST)=LHIS
      DOWN4(HIST)=DHIS
      GOTO 10
50    CONTINUE
22    MCNT=0
21    IF(MCNT.EQ.INCNT)GOTO 23
      READ(2,104)MOVE1,MOVE2,MOVE3,TYPER
104   FORMAT(4I4)
      MCNT=MCNT+1
      TOPI=INIT(MCNT)
      NAME4(TOPI)=MOVE1
      RLINK4(TOPI)=MOVE2
      LLINK4(TOPI)=MOVE3
      DOWN4(TOPI)=TYPER
      GOTO 21
23    TCONT=0
26    IF(TCONT.EQ.CONTR) GOTO 230
      READ(2,106)DEF,OFF
106   FORMAT(2I4)
      TCONT=TCONT+1
      TOPT=TYPE(TCONT)
      NAME3(TOPT)=DEF
      RLINK3(TOPT)=OFF
      CALL GET2(J)
      DOWN3(TOPT)=J
      TOPG=J
24    READ(2,109)NAMER,DOWNR
109   FORMAT(2I4)
      IF(NAMER.EQ.15.OR.NAMER.EQ.25) GOTO 580
      NAME2(TOPG)=NAMER
582   IF(DOWNR.EQ.0) GOTO 25
      CALL GET2(J)
      DOWN2(TOPG)=J
      TOPG=DOWN2(TOPG)
      GOTO 24
580   IF(NAMER.EQ.25)GOTO 581
      NAME2(TOPG)=A1
```

```
      GOTO 582
  581 NAME2(TOPG)=A2
      GOTO 582
  25  DOWN2(TOPG)=0
      GOTO 26
  230 SCNT=0
  231 IF(SCNT.EQ.SCONTR) GOTO 27
      SCNT=SCNT+1
      TOPQ=SEQ(SCNT)
      RTOPQ=TOPQ
  200 READ(2,121)TYPES,MOVI1,MOVI2,MOVI3,DOWNS
      NAME3(RTOPQ)=TYPES
      CALL GET3(L)
      RLINK3(RTOPQ)=L
      NAME3(L)=MOVI1
      RLINK3(L)=MOVI2
      DOWN3(L)=MOVI3
      IF(DOWNS.EQ.0) GOTO 31
      CALL GET3(L)
      DOWN3(RTOPQ)=L
      RTOPQ=DOWN3(RTOPQ)
      GOTO 200
  31  DOWN3(RTOPQ)=0
      GOTO 231
  121 FORMAT(5I4)
  27  RETURN
      END


      SUBROUTINE REBILD(INCNT)
C
C     SUBROUTINE TO REBUILD THE HEADER CELLS FOR THE INITIAL,
C     TYPE, AND SEQUENCE LIBRARIES.
C
      IMPLICIT INTEGER (A-W)
      COMMON/TDJE/APN,APS,STACK(40)
      COMMON/PAR/P(4),S(4),PRBLS(5)
      COMMON/EEE/EN,ES,TOPEN,TOPES
      COMMON/ENP/ENARRY(50),ESARRY(50)
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFFN,PMOVEN,PMOVES
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/ST/STRUE,LASTGO,NFLAG,TURN,ANAL,RECON
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP2/STK(10),STKM(10),STKN(10),STKNM(10)
      COMMON/TDP9/TYPENU,TYPE1
```

```
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/TDP4/SEQ(20),SCONTR
      COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CONTR
      DIMENSION COMPN(3,3)
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DATA HEADS/'HEAD'/,TAILS/'TAIL'/,YES/'YES'/,NO/' NO'/
      DATA A1/'A1'/,A2/'A2'/
      RSTK=0
      SSTK=0
      TSTK=0
11    IF(TSTK.EQ.INCNT) GOTO 40
      TSTK=TSTK+1
41    TJ=AVAIL4
      JJ=TJ
42    CALL GET4(J)
      IF(STACK(TSTK).EQ.J) GOTO 15
      RJ=JJ
      DOWN4(JJ)=AVAIL4
      JJ=DOWN4(JJ)
      GOTO 42
15    INIT(TSTK)=J
      DOWN4(RJ)=AVAIL4
      AVAIL4=TJ
      DOWN4(J)=0
      GOTO 11
40    IF(RSTK.EQ.CONTR) GOTO 400
      RSTK=RSTK+1
      TSTK=TSTK+1
      TL=AVAIL3
      LL=TL
410   CALL GET3(L)
      IF(STACK(TSTK).EQ.L) GOTO 150
      RL=LL
      DOWN3(LL)=AVAIL3
      LL=DOWN3(LL)
      GOTO 410
150   TYPE(RSTK)=L
      DOWN3(RL)=AVAIL3
      AVAIL3=TL
      GOTO 40
400   IF(SSTK.EQ.SCONTR) GOTO 450
      SSTK=SSTK+1
      TSTK=TSTK+1
      TL=AVAIL3
      LL=TL
```

```
451 CALL GET3(L)
    IF(STACK(TSTK).EQ.L) GOTO 449
    RL=LL
    DOWN3(LL)=AVAIL3
    LL=DOWN3(LL)
    GOTO 451
449 SEQ(SSTK)=L
    DOWN3(RL)=AVAIL3
    AVAIL3=TL
    GOTO 400
450 RETURN
    END


    SUBROUTINE SAVE(INCNT,INCNTR,DU)
C
C   SUBROUTINE TO SAVE DATA IN THE PERMANENT MEMORY AT THE END OF
C   A GAME OR A SERIES OF GAMES.
C
    IMPLICIT INTEGER (A-W)
    COMMON/TDJE/APN,APS,STACK(40)
    COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
    COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
    COMMON/TDP3/TYPE(20),INIT(20)
    COMMON/TDP4/SEQ(20),SCONTR
    COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CONTR
    DATA HEADS/'HEAD'/,TAILS/'TAIL'/,YES/'YES'/,NO/' NO'/
    DATA A1/'A1'/,A2/'A2'/
    DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
   1(1000),DOWN2(1000)
    EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
   12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
101 FORMAT(7I3)
    TSTK=0
    SSTK=0
    RSTK=0
401 IF(TSTK.EQ.INCNT)GOTO 400
    TSTK=TSTK+1
    STACK(TSTK)=INIT(TSTK)
    GOTO 401
400 IF(RSTK.EQ.CONTR) GOTO 500
    RSTK=RSTK+1
    TSTK=TSTK+1
    STACK(TSTK)=TYPE(RSTK)
    GOTO 400
500 IF(SSTK.EQ.SCONTR) GOTO 600
    SSTK=SSTK+1
    TSTK=TSTK+1
```

```
      STACK(TSTK)=SEQ(SSTK)
      GOTO 500
  600 TSTK=TSTK+1
      STACK(TSTK)=0
      WRITE(3,560)TSTK,(STACK(I),I=1,TSTK)
      WRITE(3,101)CATLGN,INCNT,INCNTR,CONTR,SCONTR,APN,APS
  560 FORMAT(I3,20I3)
      TOP=BOTM
      RBOTM=BOTM
      DO 20 I=1,CATLGN
      CHAR=RLINK3(TOP)
      ENPTR=NAME4(CHAR)
      AGGRS=RLINK4(CHAR)
      PARAM=LLINK4(CHAR)
      HIST=DOWN4(CHAR)
      WRITE(3,102)NAME3(TOP),NAME2(ENPTR),DOWN2(ENPTR),
     1NAME2(AGGRS),DOWN2(AGGRS),NAME4(PARAM),RLINK4(PARAM),
     2LLINK4(PARAM),DOWN4(PARAM),NAME4(HIST),RLINK4(HIST),
     3LLINK4(HIST),DOWN4(HIST)
  102 FORMAT(A4,12I3)
      IF(DU.EQ.NO)GOTO 55
      WRITE(6,103) NAME3(TOP),NAME2(ENPTR),DOWN2(ENPTR),
     1NAME2(AGGRS),DOWN2(AGGRS),NAME4(HIST),RLINK4(HIST),LLINK4(HIST),
     2DOWN4(HIST),NAME4(PARAM),RLINK4(PARAM),LLINK4(PARAM),DOWN4(PARAM)
   55 IF(TOP.EQ.CATLG) GOTO 99
      TOP=CATLG
  551 IF(DOWN3(TOP).EQ.RBOTM)GOTO 550
      TOP=DOWN3(TOP)
      GOTO 551
  550 RBOTM=TOP
   20 CONTINUE
   99 DO 22 I=1,INCNT
      TOPI=INIT(I)
      MOVE1=NAME4(TOPI)
      MOVE2=RLINK4(TOPI)
      MOVE3=LLINK4(TOPI)
      TYPER=DOWN4(TOPI)
      WRITE(3,104)MOVE1,MOVE2,MOVE3,TYPER
  104 FORMAT(4I4)
      IF(DU.EQ.NO)GOTO 56
      WRITE(6,105)INIT(I),MOVE1,MOVE2,MOVE3,TYPER
   56 RUN=1
   22 CONTINUE
      DO 23 I=1,CONTR
      TOPT=TYPE(I)
      DEF=NAME3(TOPT)
      G=0
      OFF=RLINK3(TOPT)
```

```
      WRITE(3,106)DEF,OFF
106   FORMAT(2I4)
      IF(DU.EQ.NO)GOTO 59
      WRITE(6,112)I,TOPT,DEF,OFF
112   FORMAT(5X,'TYPE(',I2,')=',I3,/2X,'DEFF=',I3,/2X,'OFF=',I3/)
 59   RTOPT=DOWN3(TOPT)
57    G=G+1
      IF(NAME2(RTOPT).EQ.A1.OR.NAME2(RTOPT).EQ.A2)GOTO 60
      WRITE(3,17)NAME2(RTOPT),DOWN2(RTOPT)
17    FORMAT(2I4)
      IF(DU.EQ.NO) GOTO 58
      WRITE(6,111)G,NAME2(RTOPT)
111   FORMAT(5X,'GROUP(',I2,')=',I4/)
58    IF(DOWN2(RTOPT).EQ.0)GOTO 23
      RTOPT=DOWN2(RTOPT)
      GOTO 57
60    IF(NAME2(RTOPT).EQ.A1) GOTO 633
      IF(DU.EQ.NO)GOTO 580
      WRITE(6,110) G,NAME2(RTOPT)
580   NAME2(RTOPT)=25
581   WRITE(3,109)NAME2(RTOPT),DOWN2(RTOPT)
      GOTO 58
109   FORMAT(2I4)
633   IF(DU.EQ.NO) GOTO 590
      WRITE(6,110) G,NAME2(RTOPT)
590   NAME2(RTOPT)=15
110   FORMAT(5X,'GROUP(',I2,')=',A4/)
      GO TO 581
23    CONTINUE
      DO 24 I=1,SCONTR
      FLAGR=0
      TOPS=SEQ(I)
117   RTOPS=TOPS
118   TYPES=NAME3(RTOPS)
      MOVI=RLINK3(RTOPS)
      MOVI1=NAME3(MOVI)
      MOVI2=RLINK3(MOVI)
      MOVI3=DOWN3(MOVI)
      IF(FLAGR.GT.0) GOTO 125
      DOWNS=DOWN3(RTOPS)
      WRITE(3,121)TYPES,MOVI1,MOVI2,MOVI3,DOWNS
121   FORMAT(5I4)
116   IF(DOWN3(RTOPS).EQ.0) GOTO 119
      RTOPS=DOWN3(RTOPS)
      GOTO 118
119   IF(DU.EQ.NO)GOTO 24
      IF(FLAGR.GT.0)GOTO 24
      WRITE(6,123) TOPS
```

```
      FLAGR=1
      GOTO 117
125   WRITE(6,124)TYPES,MOVI1,MOVI2,MOVI3
      GOTO 116
24    CONTINUE
103   FORMAT(5X,'PLAYER ',A4,2X,'ENAVG',I4,2X,'ESAVG',I4,2X,'AGG',I4/2X,
     1'HCLAS',I4,2X,'INITS',I4,2X,'INITN',I4,2X,'SEQS',I4,2X,'SEQN',I4/2
     2X,'PROB1',I4,2X,'PROB2',I4,2X,'PROB3',I4,2X,'PROB4',I4//)
105   FORMAT(5X,'INIT(',I3,')',2X,'MOVE1=',I2,2X,'MOVE2=',I2,2X,'MOVE3='
     1,I2,2X,'TYPE NUMBER=',I3//)
123   FORMAT(5X,'SEQ(',I3,')')
124   FORMAT('+',2X,'TYPE NO.',I4,2X,'INITIAL MOVES (MOV1 ',I2,2X,'MOV2
     1',I2,2X,'MOV3 ',I2,')'//)
      END FILE 3
      RETURN
      END


      SUBROUTINE CKTYP(CKGRP1,CKGRP2,NOGO,FLAG)
C
C     THIS SUBROUTINE CHECKS A CATAGORY(GROUP) TO DETERMINE IF IS
C     CLOSE ENOUGH FOR A PATTERN MATCH. (IT MUST NOT BE SEPERATED
C     BY MORE THAN ONE CATAGORY FOR TWO GROUPS IN A SEQUENCE.
C
      IMPLICIT INTEGER (A-W)
      DATA A1/'A1'/,A2/'A2'/
      IF(CKGRP1.EQ.1.OR.CKGRP1.EQ.2.OR.CKGRP1.EQ.3) GOTO 5
      IF(CKGRP1.EQ.A1) GOTO 10
      IF(CKGRP1.EQ.A2) GOTO 20
      WRITE(6,256)
256   FORMAT(5X,'CAN NOT FIND A CHECK GROUP IN SUBROUTINE CKTYP IN CLSTY
     1P SUBROUTINE'//)
      GOTO 700
5     VALUE=CKGRP1-2
      IF (VALUE) 6,7,7
6     IF(CKGRP2.EQ.A1) GOTO 66
76    IF(FLAG)666,665,666
665   NOGO=1
      RETURN
666   NOGO=0
      RETURN
66    NOGO=0
      RETURN
7     IF(CKGRP2.EQ.A2) GOTO 66
      IF (VALUE.EQ.0) GO TO 6
      GOTO 76
10    IF(CKGRP2.EQ.1.OR.CKGRP2.EQ.2) GOTO 66
      GOTO 76
```

```
20   IF(CKGRP2.EQ.2.OR.CKGRP2.EQ.3) GOTO 66
     GOTO 76
700  RETURN
     END


     SUBROUTINE TOTMV(TOTAL,GROUP)
C
C    SUBROUTINE TO CLASSIFY COMBINATIONS OF ANY THREE MOVES TO
C    PRODUCE CATAGORIES OF GROUP 1,A1,2,A2,3.
C
     IMPLICIT INTEGER (A-W)
     COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
     COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
     DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
    1(1000),DOWN2(1000)
     EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
    12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
     DATA A1/'A1'/,A2/'A2'/
     IF(TOTAL.EQ.3.OR.TOTAL.EQ.4) GOTO 4
     IF(TOTAL.EQ.5) GOTO 5
     IF(TOTAL.EQ.6) GOTO 6
     IF(TOTAL.EQ.7) GOTO 7
     IF(TOTAL.EQ.8.OR.TOTAL.EQ.9) GOTO 9
4    GROUP=1
     RETURN
5    GROUP=A1
     RETURN
6    GROUP=2
     RETURN
7    GROUP=A2
     RETURN
9    GROUP=3
     RETURN
     END


     SUBROUTINE GETMV(NXTGRU,TMOVE2,PMOVE)
C
C    SUBROUTINE TO DETERMINE NEXT MOVE FROM PREDICTED GROUP.
C
     IMPLICIT INTEGER (A-W)
     COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
     COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
     DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
    1(1000),DOWN2(1000)
     EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
    12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
```

```
      DATA A1/'A1'/,A2/'A2'/
      IF(NXTGRU.EQ.1) GOTO 10
      IF(NXTGRU.EQ.A1) GOTO 11
      IF(NXTGRU.EQ.2) GOTO 12
      IF(NXTGRU.EQ.A2) GOTO 13
      IF(NXTGRU.EQ.3) GOTO 14
10    IF(TMOVE2.EQ.2) GOTO 2
      IF(TMOVE2.EQ.3) GOTO 3
2     PMOVE=2
      RETURN
3     PMOVE=1
      RETURN
11    IF(TMOVE2.EQ.2) GOTO 22
      IF(TMOVE2.EQ.3) GOTO 23
      IF(TMOVE2.EQ.4) GOTO 24
22    PMOVE=3
      RETURN
23    PMOVE=2
      RETURN
24    PMOVE=1
      RETURN
12    IF(TMOVE2.EQ.3)GOTO 33
      IF(TMOVE2.EQ.4)GOTO 34
      IF(TMOVE2.EQ.5)GOTO 35
33    PMOVE=3
      RETURN
34    PMOVE=2
      RETURN
35    PMOVE=1
      RETURN
13    IF(TMOVE2.EQ.4)GOTO 44
      IF(TMOVE2.EQ.5)GOTO 45
      IF(TMOVE2.EQ.6)GOTO 46
44    PMOVE=3
      RETURN
45    PMOVE=2
      RETURN
46    PMOVE=1
      RETURN
14    IF(TMOVE2.EQ.6) GOTO 56
      IF(TMOVE2.EQ.5)GOTO 55
56    PMOVE=2
      RETURN
55    PMOVE=3
      RETURN
      END
```

```
      SUBROUTINE STRTOT(STRAT)
C
C     SUBROUTINE TO DETERMINE WHERE THE LAST MOVE FITS IN THE TOTAL
C     OF TYPES OF MOVES IN THE TEMPORARY MEMORY HEADER AND UPDATE THE
C     APPROPRIATE CELLS IN THE HEADER NODES.
C
      IMPLICIT INTEGER (A-W)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      IF(STRAT.EQ.1) GOTO 100
      STRTP=LLINK4(PATRNN)
      VALU1=STRATN-2
      IF(VALU1)10,20,30
10    NAME4(STRTP)=NAME4(STRTP)+1
      RETURN
20    RLINK4(STRTP)=RLINK4(STRTP)+1
      RETURN
30    LLINK4(STRTP)=LLINK4(STRTP)+1
      RETURN
100   STRTP=LLINK4(PATRNS)
      VALU1=STRATS-2
      IF(VALU1)11,21,31
11    NAME4(STRTP)=NAME4(STRTP)+1
      RETURN
21    RLINK4(STRTP)=RLINK4(STRTP)+1
      RETURN
31    LLINK4(STRTP)=LLINK4(STRTP)+1
      RETURN
      END


      SUBROUTINE TOTALM(MOVE,TOTRUE,BYPASS,INCNT,MCNT,TOTAL,TOTAL2)
C
C     THIS SUBROUTINE TOTALS THE THREE MOVES IN TEMPORAY MEMORY
C     FOR BOTH PATRNN AND PATRNS.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP/MOVES,MOVEN
      COMMON/TDP3/TYPE(20),INIT(20)
```

```
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      DATA A1/'A1'/,A2/'A2'/
      MCNT=1
      TOTAL2=0
      TOTAL=C
      IF(MOVE.EQ.MOVES)GOTO 100
      TOPMN=MOVE
  106 TOTAL=TOTAL+NAME2(TOPMN)
      IF(DOWN2(TOPMN).EQ.0) GOTO 107
      TOPMN=DOWN2(TOPMN)
      TOTAL2=TOTAL2+NAME2(TOPMN)
      GOTO 106
  100 TOPMS=MOVE
  108 TOTAL=TOTAL+NAME2(TOPMS)
      IF(DOWN2(TOPMS).EQ.0) GOTO 107
      TOPMS=DOWN2(TOPMS)
      TOTAL2=TOTAL2+NAME2(TOPMS)
      GOTO 108
  107 IF(BYPASS.EQ.0) GOTO 110
C
C     BYPASS IF YOU DO NOT WANT TO TOTAL MOVES IN THE INITIAL PATTERN.
C
  62  IF(MCNT.GT.INCNT)GOTO 64
      TOPI=INIT(MCNT)
      ITOTAL=0
      ITOTAL=ITOTAL+NAME4(TOPI)
      ITOTAL=ITOTAL+RLINK4(TOPI)
      ITOTAL=ITOTAL+LLINK4(TOPI)
      IF(TOTAL.EQ.ITOTAL)GOTO 65
      MCNT=MCNT+1
      GOTO 62
  65  TOTRUE=1
      RETURN
  64  TOTRUE=0
C
C     "0"==> NOT TRUE NO MATCH IN THE INITIAL LIBRARY.
C      "1" ==> TRUE THERE IS A MATCH IN INITIAL LIBRARY.
C
  110 RETURN
      END
```

```
      SUBROUTINE MOVEPL
C
C     SUBROUTINE TO PUT OLD PLAYER TO THE TOP OF THE CATALOGUE.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      MV=CATLG
      IF(MV.EQ.TOP) GOTO 4
    1 IF(DOWN3(MV).EQ.TOP) GOTO 2
      MV=DOWN3(MV)
      GOTO 1
    2 IF(DOWN3(MV).NE.BOTM) GOTO 3
      BOTM=MV
      DOWN3(BOTM)=0
    3 DOWN3(MV)=DOWN3(TOP)
      DOWN3(TOP)=CATLG
      CATLG=TOP
    4 RETURN
      END

      SUBROUTINE SEARCH(PLY)
C
C     SUBROUTINE TO FIND OUT IF A PLAYER IS IN THE CATALOGUE
C     OF PLAYERS
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      TOP=CATLG
    2 IF(NAME3(TOP).EQ.PLAYER) GOTO 1
      IF(DOWN3(TOP).EQ.0) GOTO 3
      TOP=DOWN3(TOP)
      GOTO 2
    3 PLY=0
      RETURN
    1 PLY=1
      RETURN
      END
```

```
      SUBROUTINE CLSMVS(MOV,INCNT,PCNT,PCNTM,INCNTR)
C
C     SUBROUTINE TO CLASSIFY INITIAL MOVES FROM SOUTHS PATTERN.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TDP5/TYPENU,TYPE1,TYSCU,TYNOR
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP4/SEQ(20),SCCNTR
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/TDP2/STK(10),STKM(10),STKN(10),STKNM(10)
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFFN,PMOVEN,PMOVES
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CONTR
      COMMON/TDP8/RLHIST,NAHIST
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      MOV2=NC
      DCNT=1
      DCT=1
      DCTM=1
      MCNT=1
      MOVES=DOWN4(PATRNS)
      IF(INCNT.EQ.0)GOTO 82
    9 TOPMS=MOVES
      IF(MOV2.GT.3) GOTO 35
   10 IF(MCNT.GT.INCNT) GOTO 20
      TOPI=INIT(MCNT)
      IF(NAME4(TOPI).EQ.NAME2(TOPMS)) GOTO 30
      MCNT=MCNT+1
      GOTO 10
   20 IF(PCNT.GT.0) GOTO 21
      DEFES=0
C     "0"==> NO DEFENSIVE STRATEGY IS AVAILABLE. FIND BEST DEFENSE
C     FOR MIXED MOVE MATCH STRATEGY.
      MCNT=1
   43 TOPMS=MOVES
   41 IF(MCNT.GT.INCNT)GOTO 40
      TOPI=INIT(MCNT)
      IF(RLINK4(TOPI).EQ.NAME2(TOPMS))GOTO 45
      MCNT=MCNT+1
      GOTO 41
```

```
40    IF(PCNTM.GT.0) GOTO 42
      BDEFS=0
      PMOVES=0
C     "0"==> BEST DEFENSE FROM MIXED MOVE STRATEGY.
      RETURN
45    DCTM=DCTM+1
      TOPMS=DOWN2(TOPMS)
      IF(NAME4(TOPI).EQ.NAME2(TOPMS)) GOTO 49
      MCNT=MCNT+1
      DCTM=1
      GOTO 43
49    POINTR=MCNT
      PCNTM=PCNTM+1
      STKM(PCNTM)=POINTR
      PTRM=POINTR
      MCNT=MCNT+1
      DCTM=1
      GOTO 43
42    IF(PCNTM.GT.1) GOTO 47
      TOPI=INIT(PTRM)
      MCNT=PTRM
46    PMOVES=LLINK4(TOPI)
      NORSO=0
      CALL CLSTYP(NORSO)
      BDEFS=DEFES
      DEFES=0
      RETURN
47    PTRM=STKM(PCNTM)
      PCNTM=PCNTM-1
      TOPI=INIT(PTRM)
      MCNT=PTRM
      GOTO 46
30    DCT=DCT+1
      TOPMS=DOWN2(TOPMS)
      IF(RLINK4(TOPI).EQ.NAME2(TOPMS)) GOTO 31
      DCT=1
      MCNT=MCNT+1
      GOTO 9
31    POINTR=MCNT
      PCNT=PCNT+1
      STK(PCNT)=POINTR
      PTR=POINTR
      DCT=1
      MCNT=MCNT+1
      GOTO 9
21    IF(PCNT.GT.1)GOTO 25
      TOPI=INIT(PTR)
      MCNT=PTR
```

```
   24 PMOVES=LLINK4(TOPI)
      NORSO=0
      CALL CLSTYP(NORSO)
      RETURN
   25 PTR=STK(PCNT)
      TOPI=INIT(PTR)
      MCNT=PTR
      GOTO 24
C
C     GET STRATEGY FOR THE FORTH MOVE AND SET UP
C     ADDITIONAL INITIAL MOVES CELLS.
   35 IF(PCNT.EQ.0) GOTO 36
      PTR=STK(PCNT)
      PCNT=PCNT-1
      TOPMS=MOVES
      DCNT=1
   39 IF(DCNT.EQ.3) GOTO 38
      TOPMS=DOWN2(TOPMS)
      DCNT=DCNT+1
      GOTO 39
   38 TOPI=INIT(PTR)
      MCNT=PTR
      IF(LLINK4(TOPI).EQ.NAME2(TOPMS)) GOTO 55
      GOTO 35
   60 MOV=1
      MOVE=MOVES
      CKINCT=INCNT
      CALL INTLIB(INCNT,MOVE,TOPI,INCNTR,MOV)
      IF(CKINCT.EQ.INCNT)GOTO 81
C     NOW CELL HAS BEEN ADDED
      MOVES=DOWN4(PATRNS)
      TOPMS=MOVES
      NAME4(TOPI)=NAME2(TOPMS)
      TOPMS=DOWN2(TOPMS)
      RLINK4(TOPI)=NAME2(TOPMS)
      TOPMS=DOWN2(TOPMS)
      LLINK4(TOPI)=NAME2(TOPMS)
      DOWN4(TOPI)=0
      GOTO 80
   36 DEFES=0
      MOVE=MOVES
      BYPASS=1
      CALL TOTALM(MOVE,TOTRUE,BYPASS,INCNT,MCNT,TOTAL,TOTAL2)
      IF(TOTRUE)64,64,65
   65 NORSO=0
      IF(DOWN4(MCNT).EQ.0)GOTO 650
      TOPI=INIT(MCNT)
      IF (DOWN4(TOPI).EQ.0) GO TO 650
```

```
      TYPENU=DOWN4(TOPI)
 65C  CALL CLSTYP(NORSO)
      PDEFS=DEFES
      DEFES=0
      GOTO 6C
 64   DEFES=0
      PDEFS=0
      GOTO 6C
 55   NORSO=0
      CALL CLSTYP(NORSO)
      GO TO 60
 80   NAHIST=INIT(INCNT)
      RETURN
 81   NAHIST=TOPI
      RETURN
 82   IF(MOV2.GT.3)GOTO 60
      DEFES=0
      PDEFS=0
      PMOVES=0
      RETURN
      END


      SUBROUTINE CLSTYP(NORSC)
C
C     SUBROUTINE TO DETERMINE IF A PLAYER FITS A PARTICULAR
C     PATTER IN THE TYPE LIBRARY AND IF SO OBTAIN THE PREDICTED
C     MOVE FOR THE BEST DEFFENSIUE OR OFFENSIUE MOVE FOR THE
C     MATCHED PATTERN.
C
C     NORSO==> NORTH OR SOUTH 1==> NORTH (COMPUTER)
C                             0==> SOUTH (PLAYER)
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP9/TYPENU,TYPE1,TYSOU,TYNOR
      COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CONTR
      COMMON/TDP4/SEQ(20),SCONTR
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFFN,PMOVEN,PMOVES
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
```

```
      TOT=0
      TFLAG=0
      IF(NC.GT.3) GOTO 11
      CALL FINDTY(MCNT,TYPENU,NORSO)
      IF(TYPENU.EQ.0) GOTO 100
      TYPE1=TYPENU
      IF(NC.EQ.3) GOTO 10
      IF(NC.EQ.2) GOTO 1
      IF(NORSO.EQ.1)GOTO 2
      TYSOU=TYPE1
      PMOVES=NAME3(TYPE1)
      RETURN
2     PMOVEN=NAME3(TYPE1)
      TYNOR=TYPE1
      RETURN
1     IF(NORSO.EQ.1) GOTO 3
      PMOVES=RLINK3(TYPE1)
      TYSOU=TYPE1
      RETURN
3     PMOVEN=RLINK3(TYPE1)
      TYNOR=TYPE1
      RETURN
10    MOVE=DOWN4(PATRNS)
      IF(NORSO.EQ.1)MOVE=DOWN4(PATRNN)
6     TOT=TOT+NAME2(MOVE)
      IF(DOWN2(MOVE).EQ.0) GOTO 5
      MOVE=DOWN2(MOVE)
      GOTO 6
5     IF(NORSO)555,554,555
554   TYSOU=TYPE1
      GOTO 556
555   TYNOR=TYPE1
556   FINDGU=DOWN3(TYPE1)
      NXTGRU=NAME2(DOWN2(FINDGU))
      TMOVE2=TOT
      CALL GETMV(NXTGRU,TMOVE2,PMOVE)
      IF(NORSO.EQ.1)GOTO 50
      PMOVES=PMOVE
      DEFES=NAME3(TYPE1)
      OFFES=RLINK3(TYPE1)
      TYPE1=0
      RETURN
50    PMOVEN=PMOVE
      DEFEN=NAME3(TYPE1)
      OFFEN=RLINK3(TYPE1)
      IF (DEFES.EQ.OFFEN) GO TO 90
      IF (DEFEN.EQ.0) GO TO 90
      IF(OFFES.EQ.DEFEN) GOTO 51
```

```
      IF(NC.LE.3) RETURN
      GOTO 11
51    IF (NC.GT.4.AND.TFLAG.EQ.0) RETURN
      TFLAG=0
      FINDGU=DOWN3(DEFEN)
      TYNOR=DEFEN
      NXTGRU=NAME2(DOWN2(FINDGU))
      CALL GETMV(NXTGRU,TMOVE2,PMOVE)
      PMOVEN=PMOVE
      TYPE1=0
      RETURN
11    IF(TYPENU.EQ.0) GOTO 100
      IF(NORSO)777,770,777
770   IF(TYSOU.NE.0) GOTO 110
      TYSOU=TYPENU
110   TYPE1=TYSOU
      GOTO 112
777   IF(TYNOR.NE.0) GOTO 111
      TYNOR=TYPENU
111   TYPE1=TYNOR
112   DOWNTY=DOWN3(TYPE1)
      FINDGU=DOWN2(DOWNTY)
      IF(NORSO.EQ.1) GOTO 41
      PATRN=PATRNS
      TMOVE2=TMOVES
40    STRTP=LLINK4(PATRN)
      TOPGP=DOWN4(STRTP)
      DOWNPT=TOPGP
      GOTO 42
41    PATRN=PATRNN
      TMOVE2=TMOVEN
      GOTO 40
42    IF(DOWN2(DOWNPT).EQ.0) GOTO 45
      IF(DOWN2(FINDGU).EQ.0) GOTO 49
      TOPGU=DOWNPT
      TOPTY=DOWNTY
      DOWNPT=DOWN2(DOWNPT)
      DOWNTY=DOWN2(DOWNTY)
      FINDGU=DOWN2(DOWNTY)
      GOTO 42
45    IF(NAME2(DOWNPT).EQ.NAME2(DOWNTY)) GO TO 47
      FLAG=0
      IF(NAME2(TOPGU).EQ.NAME2(TOPTY)) GOTO 48
      CKGRP1=NAME2(TOPGU)
      CKGRP2=NAME2(TOPTY)
80    CALL CKTYP(CKGRP1,CKGRP2,NOGO,FLAG)
      IF(NOGO.EQ.1) GOTO 49
47    NXTGRU=NAME2(FINDGU)
```

```
471 CALL GETMV(NXTGRU,TMOVE2,PMOVE)
    IF(NORSO.EQ.1) GOTO 43
    PMOVES=PMOVE
    DEFES=NAME3(TYPE1)
    OFFES=RLINK3(TYPE1)
    TYPE1=0
    RETURN
43  PMOVEN=PMOVE
    DEFEN=NAME3(TYPE1)
    OFFEN=RLINK3(TYPE1)
    IF (DEFES.EQ.OFFEN) GO TO 90
    IF (DEFEN.EQ.0) GO TO 90
    IF (OFFES.EQ.DEFEN) GO TO 51
    RETURN
48  FLAG=1
    CKGRP1=NAME2(DOWNPT)
    CKGRP2=NAME2(DOWNTY)
    GOTO 80
49  CONT=1
53  IF(CONT.GT.CONTR) GOTO 56
    TOPGP=DOWN3(TYPE(CONT))
    NXTGP=DOWN2(TOPGP)
    IF(NAME2(TOPGU).EQ.NAME2(TOPGP)) GOTO 57
    CKGRP1=NAME2(TOPGU)
    CKGRP2=NAME2(TOPGP)
    CALL CKTYP(CKGRP1,CKGRP2,NOGO,FLAG)
    IF(NOGO.EQ.0)GOTO 57
    CONT=CONT+1
    GOTO 53
57  FLAG=1
    IF(NAME2(DOWNPT).EQ.NAME2(NXTGP))GOTO 58
    CKGRP1=NAME2(DOWNPT)
    GKGRP2=NAME2(NXTGP)
    CALL CKTYP(CKGRP1,CKGRP2,NOGO,FLAG)
    IF(NOGO.EQ.0)GOTO 58
    CONT=CONT+1
    GOTO 53
56  IF(NORSO.EQ.1) GOTO 52
    PMOVES=0
    RETURN
52  PMOVEN=0
    RETURN
58  IF(NORSO.EQ.1) GOTO 55
    TYSOU=TYPE(CONT)
    NXTGRU=NAME2(NXTGP)
    TYPE1=TYPE(CONT)
    GO TO 471
55  TYNOR=TYPE(CONT)
```

```
      TYPE1=TYPE(CONT)
      NXTGRU=NAME2(NXTGP)
      TFLAG=1
      GO TO 471
 100  PMOVES=0
      PMOVEN=0
      RETURN
 90   TYPE1=0
      RETURN
      END


      SUBROUTINE CLSMVN(MOV,INCNT,PCNTN,PCNTNM,INCNTR)
C
C     SUBROUTINE TO CLASSIFY INITIAL MOVES FROM NORTHS PATTERN.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/TDP4/SEQ(20),SCONTR
      COMMON/TDP2/STK(10),STKM(10),STKN(10),STKNM(10)
      COMMON/TDP9/TYPENU,TYPE1,TYSOU,TYNOR
      COMMON/TDP8/RLHIST,NAHIST
      COMMON/CLS/DEFES,BDEFS,OFFEN,BOFFN,PMOVEN,PMOVES
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,PW,NC,INRAND,YRAND,EFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      COMMON/TDP7/GROUPS,GROUPN,TMOVES,TMOVEN,MCNT,CONTR
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      MOV2=NC
      DCNT=1
      DCT=1
      DCTM=1
      MCNT=1
      MOVEN=DOWN4(PATRNN)
      IF(INCNT.EQ.0)GOTO 82
 9    TOPMN=MOVEN
      IF(MOV2.GT.3) GOTO 35
 10   IF(MCNT.GT.INCNT) GOTO 20
      TOPI=INIT(MCNT)
      IF(NAME4(TOPI).EQ.NAME2(TOPMN)) GOTO 30
      MCNT=MCNT+1
      GOTO 10
 20   IF(PCNTN.GT.0) GOTO 21
```

```
      OFFEN=0
C     "0"==> NO DEFENSIVE STRATEGY IS AVAILABLE. FIND BEST DEFENSE
C     FOR MIXED MOVE MATCH STRATEGY.
      MCNT=1
   43 TOPMN=MOVEN
   41 IF(MCNT.GT.INCNT)GOTO 40
      TOPI=INIT(MCNT)
      IF(RLINK4(TOPI).EQ.NAME2(TOPMN))GOTO 45
      MCNT=MCNT+1
      GOTO 41
   40 IF(PCNTNM.GT.0) GOTO 42
      BOFFN=0
      PMOVEN=0
C     "0"==> BEST DEFENSE FROM MIXED MOVE STRATEGY.
      RETURN
   45 DCTM=DCTM+1
      TOPMN=DOWN2(TOPMN)
      IF(NAME4(TOPI).EQ.NAME2(TOPMN)) GOTO 49
      MCNT=MCNT+1
      DCTM=1
      GOTO 43
   49 POINTR=MCNT
      PCNTNM=PCNTNM+1
      STKNM(PCNTNM)=POINTR
      PTRM=POINTR
      MCNT=MCNT+1
      DCTM=1
      GOTO 43
   42 IF(PCNTNM.GT.1) GOTO 47
      TOPI=INIT(PTRM)
      MCNT=PTRM
   46 PMOVEN=LLINK4(TOPI)
      NORSO=1
      CALL CLSTYP(NORSO)
      BOFFN=OFFEN
      OFFEN=0
      RETURN
   47 PTRM=STKNM(PCNTNM)
      PCNTNM=PCNTNM-1
      TOPI=INIT(PTRM)
      MCNT=PTRM
      GOTO 46
   30 DCT=DCT+1
      TOPMN=DOWN2(TOPMN)
      IF(RLINK4(TOPI).EQ.NAME2(TOPMN)) GOTO 31
      DCT=1
      MCNT=MCNT+1
      GOTO 9
```

```
   31 POINTR=MCNT
      PCNTN=PCNTN+1
      STKN(PCNTN)=POINTR
      PTR=POINTR
      DCT=1
      MCNT=MCNT+1
      GOTO 9
   21 IF(PCNTN.GT.1)GOTO 25
      TOPI=INIT(PTR)
      MCNT=PTR
   24 PMOVEN=LLINK4(TOPI)
      NORSO=1
      CALL CLSTYP(NORSO)
      RETURN
   25 PTR=STKN(PCNTN)
      TOPI=INIT(PTR)
      MCNT=PTR
      GOTO 24
C
C     GET STRATEGY FOR THE FORTH MOVE AND SET UP
C     ADDITIONAL INITIAL MOVEN CELLS.
   35 IF(PCNTN.EQ.0) GOTO 36
      PTR=STKN(PCNTN)
      PCNTN=PCNTN-1
      TOPMN=MOVEN
      DCNT=1
   39 IF(DCNT.EQ.3) GOTO 38
      TOPMN=DOWN2(TOPMN)
      DCNT=DCNT+1
      GOTO 39
   38 TOPI=INIT(PTR)
      MCNT=PTR
      IF(LLINK4(TOPI).EQ.NAME2(TOPMN)) GOTO 55
      GOTO 35
   60 MOV=1
      MOVE=MOVEN
      CKINCT=INCNT
      CALL INTLIB(INCNT,MOVE,TOPI,INCNTR,MOV)
      IF(CKINCT.EQ.INCNT)GOTO 81
C     NOW CELL HAS BEEN ADDED
      MOVEN=DOWN4(PATRNN)
      TOPMN=MOVEN
      NAME4(TOPI)=NAME2(TOPMN)
      TOPMN=DOWN2(TOPMN)
      RLINK4(TOPI)=NAME2(TOPMN)
      TOPMN=DOWN2(TOPMN)
      LLINK4(TOPI)=NAME2(TOPMN)
      DOWN4(TOPI)=0
```

```
      GOTO 80
36    OFFEN=0
      BYPASS=1
      MOVE=MOVEN
      CALL TOTALM(MOVE,TOTRUE,BYPASS,INCNT,MCNT,TOTAL,TOTAL2)
      IF(TOTRUE)64,64,65
65    NORSO=1
      IF (MCNT.GT.INCNT) GO TO 650
      TOPI=INIT(MCNT)
      IF (DOWN4(TOPI).EQ.0) GO TO 650
      TYPENU=DOWN4(TOPI)
650   CALL CLSTYP(NORSO)
      BOFFN=OFFEN
      OFFEN=0
      GOTO 60
64    OFFEN=0
      BOFFN=0
      GOTO 60
55    NORSO=1
      CALL CLSTYP(NORSO)
      GOTO 60
80    RLHIST=INIT(INCNT)
      RETURN
81    RLHIST=TOPI
      RETURN
82    IF(MOV2.GT.3)GOTO 60
      OFFEN=0
      BOFFN=0
      PMOVEN=0
      RETURN
      END

      SUBROUTINE FINDTY(MCNT,TYPENU,NORSO)
C
C     SUBROUTINE TO FIND A HEADER NODE IN THE TYPE LIBRARY IF A
C     PLAYER HAS PLAYED BEFORE AND IS IN THE CATALOGUE OF PLAYERS.
C
      IMPLICIT INTEGER (A-W)
      COMMON/T/AVAIL4,AVAIL3,AVAIL2,NAME4(1000),NAME2(1000),NAME3(1000)
      COMMON/TD/TOP,BOTM,CATLG,CHAR,HIST,PLAYER,CATLGN,PATRNS,PATRNN
      COMMON/TDP4/SEQ(20),SCONTR
      COMMON/TDP3/TYPE(20),INIT(20)
      COMMON/JEC/VALUE(7,3),RTABN(3,3),RTABS(3,3),ATABN(3),ATABS(3),
     1SN,SS,WN,WS,RS,RW,NC,INRAND,YRAND,FFLAG,CPN,CPS,STRATN,STRATS,
     2PNOLD,ISN,ISS,ECNXN,ECNXS,PN,PS,FACTXN,FACTXS
      DIMENSION RLINK4(1000),LLINK4(1000),DOWN4(1000),RLINK3(1000),DOWN3
     1(1000),DOWN2(1000)
```

```
      EQUIVALENCE (NAME4(4),RLINK4(3),LLINK4(2),DOWN4(1)),(NAME2(2),DOWN
     12(1)),(NAME3(3),RLINK3(2),DOWN3(1))
      IF(NC.LT.2)GOTO 20
      IF(NC.GT.3) GOTO 20
      TOPI=INIT(MCNT)
      IF(DOWN4(TOPI).EQ.0) GOTO 20
      TYPENU=DOWN4(TOPI)
      RETURN
   20 IF(NORSO.EQ.1) GOTO 21
      IF(NAME4(HIST).EQ.0) GOTO 22
      INITN=NAME4(HIST)
      IF(DOWN4(INITN).EQ.0) GOTO 22
      TYPENU=DOWN4(INITN)
      RETURN
   21 IF(RLINK4(HIST).EQ.0) GOTO 32
      INITN=RLINK4(HIST)
      IF(DOWN4(INITN).EQ.0) GOTO 32
      TYPENU=DOWN4(INITN)
      RETURN
   22 IF(LLINK4(HIST).EQ.0) GOTO 42
      SEQN=LLINK4(HIST)
      RTOP=SEQN
   40 IF(DOWN3(RTOP).EQ.0) GOTO 43
      RTOP=DOWN3(RTOP)
      GOTO 40
   43 TYPENU=NAME3(RTOP)
      RETURN
   32 IF(DOWN4(HIST).EQ.0) GOTO 42
      SEQN=RLINK4(HIST)
      RTOP=SEQN
      GOTO 40
   42 TYPENU=0
      RETURN
      END
```

BIBLIOGRAPHY

1. Baker, F. B., "An IPL-V Program for Concept Attainment," Educational and Psychological Measurement, v. 24, p. 119-127, Spring 1964.

2. Baker, F. B., "The Internal Organization of Computer Models of Cognitive Behavior," Behavioral Science, v. 12, p. 156-161, March 1967.

3. Beurle, R. L., "Storage and Manipulation of Information in Random Networks," Aspects of the Theory of Artificial Intelligence, p. 19-42, Plenum Press, 1962.

4. Friedell, M. F., "On the Structure of Shared Awareness," Behavioral Science, v. 14, p. 28-39, January 1969.

5. Guetzkow, H., "A Use of Simulation in the Study of Inter-Nation Relations," Behavioral Science, v. 4, p. 183-191, July 1959.

6. Lave, L. B., "Factors Affecting Co-operation in the Prisoner's Dilemma," Behavioral Science, v. 10, p. 26-38, January 1965.

7. Luce, R. D., Raiffa, H., Games and Decisions, p. 95, Wiley, 1957.

8. Messick, D. M., "Interdependent Decision Strategies in Zero-Sum Games: A Computer Controlled Study," Behavioral Science, v. 12, p. 33-48, January 1967.

9. Piaget, J., Play, Dreams, and Imitation in Childhood, Norton, 1962.

10. Piaget, J. The Growth of Logical Thinking from Childhood to Adolescence, Basic Books, 1958.

11. Piaget, J. The Origins of Intelligence in Children, Norton, 1963.

12. Rapoport, A. and Orwant, C., "Experimental Games: A Review," Behavioral Science, v. 7, p. 1-37, January 1962.

13. Strub, M. H., "Experienced and Prior Probability in a Complex Decision Task," Journal of Applied Psychology, v. 53, p. 112-117, April 1969.

14. Swensson, R., "Cooperation in the Prisoner's Dilemma Game I: The Effects of Asymmetric Payoff Information and Explicit Communication," Behavioral Science, v. 12, p. 314-322, July 1967.

15. Taber, C. W., Taber's Cyclopedic Medical Dictionary, Davis, 1965.

16. Tuttle, W. W. and Schottelius, B. A., Textbook of Psysiology, Mosby, 1965.

17. Walton, R. E. and McKersie, R. B., "Bargaining Dilemmas in Mixed-Motive Decision Making," Behavioral Science, v. 10, p. 370-384, September 1966.

18. Weil, R. L., "The N-Person Prisoner's Dilemma: Some Theory and a Computer-Oriented Approach," Behavioral Science, v. 11, p. 227-233, May 1966.

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13. ABSTRACT

The purpose of this thesis is a discussion of developing human-like behavior in the computer. A theory of the human learning processes is first described. This leads to the presentation of a computer game which simulates the human capabilities of reasoning and learning. The program is required to make intelligent decisions based on past experiences and critical analysis of the present situation.

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